INTERNATIONAL LEAD ZINC RESEARCH ORGANIZATION, INC.

TENTH GALFAN LICENSEES MEETING

May 20/21, 1987

Pittsburgh, PA., U.S.A.

Confidential to Licensees

MINUTES OF THE TENTH GALFAN LICENSEES MEETING
OPERATING SESSION

Held at:

The Pittsburgh Hilton
Pittsburgh, PA., U.S.A.
On
May 20, 1987

ATTENDANCE:

Name	Company	May 20 Operations/Research	May 21 Marketing
E. Adamczyk	Weirton Steel	X	
D. Adkins	Bundy Corporation	X	X
J. Alfano	Stelco Inc.	X	X
C. Allen	Cominco Metals	X	X
C. Ayoub	CRM	X	X
H. Barzoukas	Ziegler	X	X
R. Bauman	Inland Steel		X
S. Belisle	Noranda	X	X
J. Branciaroli	Mineral Research	X	X
J. Brinsky	Weirton Steel	X	X
R. Brooks	Bundy	X	X
A. Celestin	Weirton Steel	X	X
T. Chattopadhyay	Nippon Denro Ispat Ltd.	X	X
J. Cole	ILZRO	X	X
G. Dallier	Stelco, Inc.	X	
P. DePaul	Weirton Steel	X	X
B. Dugan	St. Joe	X	
G. Durand	F.F. Maubeuge	X	X
P. Elser	Indiana Steel & Wire	X	X
J. Falciglia	AFC/Nortek	X	X
J. Gimigliano	Gregory Galvanizing	X	X
R. Goodhart	Weirton Steel	X	
F. Goodwin	ILZRO	X	X
Y. Hirose	Nisshin Steel	X	X
H. Hodds	Stelco, Inc.	X	
G. Hook	New Zealand Steel	X	X
J. Hostetler	Hostetler & Decker		X
R. Hurst	Indiana Steel & Wire		X
Y. Kim	Inland Steel	X	X
Y. Kobayashi	Nisshin Steel	X	X
J. Lait	Stelco, Inc.	X	
E. Lastra	Ensisteel, Inc. (Ensidesa)	X	X
R. Leonard	USS/USX Corporation	X	X
G. Lewis	Cominco Metals	X	X
T. Lindfors	Rasmet Co.	X	X

R. Lynch	Zinc Institute	X	X
D. MacDonald	Stelco, Inc.	X	
E. MacKinnon	Stelco, Inc.	X	
J. Malmgreen	Eastern Alloys	X	X
J. Maslet	Ziegler	X	X
A. Matthews	British Steel Corporation	X	X
K. McGuire	Falconbridge		X
F. Nieberding	Mannesmann-Demag Corporation		X
T. Nishi	Sumitomo Metal America		X
Y. Oishi	Kawatetsu Galvanizing	X	X
R. Palmer	Bundy Corporation	X	X
M. Pelkkikangas	Rautaruukki Oy	X	X
J. Pesonen	Outokumpu Oy	X	
B. Renaux	CRM	X	X
N. Rickard	Australian Assoc. Smelters	X	X
M. Roman	ILZRO	X	X
L. Roudabush	USS/USX Corporation	X	X
R. Sempels	Vieille-Montagne	X	X
J. Sheehan	USS/USX Corporation	X	
Y. Shimada	Sumitomo Metal	X	X
J. Siple	USS/USX Corporation	X	
P. Sippola	Rasmet Co.	X	X
G. Skubick	Eastern Alloys	X	X
J. Smith	Inland Steel		X
T. Suzuki	Nippon Denro Mfg. Co. Ltd.	X	X
J. Takasaki	Kawasaki Steel, NY, Inc.	X	X
S. Thakur	Nippon Denro Ispat Ltd.	X	X
J. Toni	Falconbridge (Kidd Creek Div)		X
M. Vveich	Weirton Steel	X	
J. Wegria	Vieille-Montagne	X	X
S. Yamamoto	Mitsui Mining & Smelting	X	X

MEETING CONVENED:

The meeting was convened by Dr. Goodwin, chairman, at 9:30 a.m. He welcomed the licensees to this first licensees meeting ever in North America and gave thanks to Weirton Steel for their sponsorship of the very successful plant tour and luncheon afterwards the day before. He noted that Weirton had been very open-handed with the information on their GALFAN production techniques and urged that licensees share the same attitude which would make the meeting more of a success. He then introduced Dr. Jerome Cole, President, ILZRO.

Dr. Cole also welcomed the attendees and noted ILZRO's relocation to Research Triangle Park, North Carolina, since the last licensees meeting in Siegen, West Germany. He then introduced Marshall P. Roman, the newly-appointed Director of the newly-formed GALFAN Technical Resource Center, citing the importance of such a center due to the growing importance of GALFAN in coated metals market.

Dr. Goodwin then asked the attendees to introduce themselves and an attendance roster was circulated.

CRM REVIEW OF COATING DEFECTS RESEARCH:

Mr. Renaux reviewed recent and ongoing CRM research on the origins of defects on GALFAN coated sheet and the influence of some processing parameters on the quality of GALFAN coated sheet. There are three areas of process development work ongoing at CRM. The first is the study of grain boundary dents. Second, a general study of coating defects, and third a study of intermetallic growth in the case of heavy gauge steel sheets. Pertinent information and slides concerning these studies are shown as an attachment to these minutes.

Mr. Renaux commenced his discussion with the study of grain boundary dents. These dents are mainly observed within eutectic structure and appear as solidification shrinkage as observed on the steel sheet. The dents cannot be eliminated by a skin pass temper-rolling operation even with higher reductions, in fact, that operation will induce another type of defect which is the formation of pin holes due to GALFAN alloy pickup on the skin pass rolls. The dents are cosmetically objectionable for GALFAN sheet that must be coil coated. The formation of the dents may be inhibited by reducing the amount of aluminum to 4.6 or 4.7% or even less, however, the corrosion resistance at these low aluminum contents must be checked. There are some contradictory results concerning the effect of cooling rate. The concentration of zinc rich particles at the coating surface promoted by an increased cooling rate would be favorable to avoid the dents (again the effect on corrosion resistance must be checked). There are studies showing that a minimum spangle coating with a rapid cooling leads to grains or spangles which are much more numerous with numerous deep narrow dents; whereas with a slow cooling the dents are wider and more shallow. The eutectic structure can be achieved by different means: the adjustment of the aluminum content using very high cooling rates of about 100 to 200°C per second and grain refining with zirconium additions. On industrial samples the grain boundary dent is seen as a depression along the grain boundaries where depth is greatest at the ternary points, usually three to five microns deep. At these ternary points, there is often a clustering of primary phase zinc rich globules. The presence of these zinc globules near the dents may be explained by a local depletion of aluminum. A 1984 industrial campaign was made at Ziegler in order to achieve a fully eutectic structure by means of zirconium additions as a grain refiner at about 0.02%. An increased surface roughness was observed. The roughness was due to very deep dents of about 10 to 15 microns depth and the boundaries between the spangles were cracked. Further studies at CRM checked the influence of aluminum at the ASTM limits of 4.7 to 6.2% and the influence of silicon additions. (The corrosion effects at these various aluminum levels will be reported later.) At a few thousandths of a percent of silicon the 4.7% aluminum mix shows a quite smooth surface without any dents. At the eutectic, 5.2% aluminum, the dents are deep (4 to 6 microns and numerous). At the hyper-eutectic composition of 6.2% aluminum the dents are about 5 microns deep but are much less numerous, but the cracking of the coating is more severe and the boundaries are wider. Now, this year a series of simulation trials has been initiated to check the effects of aluminum between 4.0% and 5.2%. Also, the effect of magnesium on grain boundary dents will be evaluated. Experimental parameters will closely match those used for common licensee practice conditions. Aspects to be checked are roughness measurements, metallographic cross sections at the grain boundary dents, SEM surface studies, and coating adherence tests along with corrosion resistance tests, both accelerated and long term atmospheric exposure. Next, the growth of grain boundary dents was simulated by observing the solidification of large cast ingots of simulated GALFAN alloy. The dent shrinkage is more pronounced when the aluminum content is increased, especially for the bath simulation of 4.82% aluminum. In the cast ingot study, this bath is the only one which produced the grain boundary dents. These observations concerning the shrinkage are rather surprising, because the soundness of cast alloys is generally better when the solidification interval is reduced (i.e. when the aluminum content is higher). An eutectic structure should give rise to an instantaneous and uniform solidification which is contrary what is observed in industrial and laboratory samples.

GENERAL COATING DEFECTS:

Mr. Renaux started by relating that the actual origin of some coating defects is not easy to find owing to the complexity of the galvanizing process. Four main classes of defects have been identified: wettability problems, entrapment of particles, improper wiping conditions, and cooling and solidification problems. The results of those studies are included in progress report #16B. The further evaluation of these coating defects will continue in 1987 by studying materials supplied by licensees. Two specific types of coating defects are classified as ripples or tears (which are local over-thicknesses) and edge over-coating or feathering. The ripples are characterized by the local over-thickness followed by a very thin (less than 5 micron) area where pin holes may be observed. The feathering usually occurs on especially heavy coatings, heavy gauge steel, or low line speed usage. The feathering is characterized by over-thickness on the edges of the strip with a peculiar surface aspect showing areas with white oxide skin nearly perpendicular to the rolling axis. The coating ripples result from the high fluidity of the GALFAN alloy, along with the interaction between the wiping and the oxidized outer layer of the coating. These oxides increase the surface tension of the liquid and give rise to the ripples during the wiping. A comparison can be made to the bamboo effect often observed in GALFAN coated wire. The ripples are promoted by too strong a wiping action (too high wiping pressures) which are used to obtain thin coatings, and also by the vibration of the strip. It would be beneficial to increase the base metal roughness of the incoming strip following the experiences of some licensees, the exit and wiping under nitrogen atmosphere is the best means to avoid ripples. An additional benefit of nitrogen wiping is that the same coating thickness may be achieved with a lower gas pressure at the air knifes. Returning to the edge feathering, it is seen that the defect is an alternating of smooth and grooved areas, the latter being very irregular in thickness. It can be seen that dents along with clusters of zinc particles are observed at the joining areas between smooth areas and over-coated areas.

GROWTH OF INTERMETALLICS:

Mr. Renaux then related his latest studies on the growth of intermetallics on heavy gauge material during the GALFAN coating process. For gauge thickness of greater than 1.5 to 2.0 millimeters, the heat input from the slow moving strip is higher and the immersion time is longer. This causes bath temperature to rise which induces an irregular intermetallic compound growth, which can reach the surface of the coating and therefore decrease the corrosion resistance. In order to prevent this phnenomenon, it is necessary to reduce the inlet temperature depending on strip thickness but this may also cause wettability problems. It was found during the 1986 studies that significant inhibition of this intermetallic growth was found with the addition of silicon to a maximum specification level of 0.015%. Plans of studies for 1987 include dropping the silicon level to less than 0.015% in order to study the iron aluminum reaction for different bath temperatures ranging between 450° to 480°C. Included in this study will be the effect of high and low cooling rates and influence of sheet thickness for cold roll and hot roll. The accompanying aluminum content of the bath will be determined by the studies on the grain boundary dents. Mr. Renaux then said that for the usual strip thicknesses of approximately .8 millimeters and normal galvanizing or galfanizing conditions, normal cross sectional micrographs don't reveal any intermetallic compound at the surface but even in that case, there is some aluminum enrichment at the interface. This can only be revealed by selective pickling and specialized investigative processes. By these processes, three types of areas are observed: smooth areas, areas with ridges, and clusters of crystals. These areas show the variations in aluminum content at the surface which result from an irregular iron aluminum reaction. The smooth areas show a very thin (about .1 micron or less) aluminum rich layer. The aluminum content of pure intermetallic compounds here can be approximately 50%. The ridges areas are usually more irregular and the intermetallic layer is usually thicker. In the third area of clustered crystals, the growth of intermetallic compounds is more important and the thickness is about 0.5 to 1 micron.

Mr. Renaux concluded his presentation by saying that the iron aluminum reaction is effective in all areas of the steel surface even with normal galvanizing conditions. The intermetallic layer is very thin and irregular but can increase when strip thickness and immersion time in the bath are increased. Future studies will utilize this iron aluminum reaction to study the effect of silicon additions for inhibition and control of the iron aluminum reaction. These studies are closely related to studies of the amount of bath aluminum which is critical in the control of grain boundary dents. The identification and study of GALFAN defects is far along now, to the point where the origins of these defects are well understood and their solutions are within reach.

ASTM STANDARD SPECIFICATION A875:

Dr. Lynch of the Zinc Institute opened the discussion on the development of the above noted specification. He noted that it was approved for 1987 and discussed the incorporation of Superzinc to the specification. There is a proposed revision to the specification labeled draft #5, a copy of which is attached to these minutes. Dr. Lynch prefaced further discussion by adding that technical justification is always needed for any kind of change to an ASTM standard specification. He then referred to table 21 in the proposed revision draft #5. That table 21 specifies the chemical requirements for the addition of Superzinc. Dr. Lynch referred to a memo from the ASTM committee currently working on the ASTM revision concerning six main points of information brought to light by Nippon Steel. A copy of this committee correspondence is also attached to the minutes. The six major points of interest are:

1. Nippon Steel currently can produced heavy coating weights in the GF210 and GF235 range.

2. Nippon Steel also contends that iron in the coating in amounts up to 0.02% is not harmful and such a limit of iron should be incorporated into this specification.

3. Nippon Steel has no indication of magnesium being lost in the bath and does not consider the magnesium range in the proposed draft revision to be too restrictive.

4. Nippon Steel contends that there is an aluminum drop-off of about 1/2% from ingot to bath.

5. It is Nippon Steel's opinion that a bath analysis will be equal or equivalent to analysis of the sheet coating, therefore bath analysis control is equivalent to control of the analysis of the coating.

6. There has been no action taken to have specification coverage of the coating alloy ingots and in Nippon Steel's opinion such a specification is not necessary.

Dr. Goodwin then referred to the GALFAN specification ASTM B750 which specifies that magnesium is allowed if specified by the buyer up to 0.1%

maximum. Dr. Lynch noted that Superzinc is an addition to the GALFAN specification, not a combination of the two. At that point, Dr. Goodwin invited comments from the group on any previous points raised. Mr. Gimigliano of Gregory Galvanizing noted their problems with iron dissolution noting that they can not jet cool their strip which is normally a heavy gauge strip. Gregory Galvanizing runs hot rolled material and must enter the bath at 1000^{O}F for good GALFAN alloy adherence. This heats the pot up but it also allows for the iron aluminum reaction which then floats out as surface dross and gets on the coating. Gregory Galvanizing would like to cool the strip but they do not have the facilities in line to cool this hot roll strip. Dr. Goodwin then reminded the group that the maximum solubility of iron in the GALFAN alloy at normal bath operating temperatures is 0.4 to 0.5% maximum. Mr. Gimigliano noted that the bath analysis of iron was 0.075% causing an iron precipitation which appeared as top dross. Mr. Renaux noted that silicon should control the iron dissolution and suggested a concentration of silicon at 0.005% which should help deal with the higher strip entry temperature and maintain good wettability. At that point, Mr. Ralph Leonard noted that silicon does inhibit the iron dissolution but cautioned that silicon and iron will also float off as top dross. He suggested that the discussion should be maintained on dissolved iron and not include in the analysis any iron included in the dross. Dr. Goodwin then asked the group if there was any experience with a good top limit to dissolved iron. As there were no comments on the previous question Dr. Goodwin moved on to the discussion of aluminum levels referring to the ASTM chemical standards. He referred back to the research studies and questioned the aluminum levels effect on solidification and wettability and raised the question "Is the GALFAN alloy's solidification behavior influenced more by shaking or wettability?" and asked the group if there was any commercial experience regarding aluminum composition variance. Bob Goodhart noted that Weirton Steel had no actual work experience performed with various aluminum levels in the bath. Dr. Lynch then asked of the group what was the best GALFAN alloy composition for commercial applications, and questioned if there was any impact on the market or the marketplace. At that point, Mr. Celestin noted that grain boundary dents are only a problem on pre-painted material at Weirton Steel and had seen on other objections for applications that were not painted. Dr. Lynch then asked if a different ASTM specification is necessary (i.e. for different end use products). He noted that information on product performance (such as ongoing research at CRM) would be necessary prior to making a change.

Dr. Hirose noted that Nisshin had confirmed the effects of varying aluminum contents and had already previously presented data on this problem. He stated that the Nisshin product had the same cosmetic appearance at a 4% aluminum level as did product at 5.2% aluminum level except there were no grain boundary dents and then recommended that a lower aluminum content such as 4.2% be established for the GALFAN alloy. Dr. Goodwin then pointed out to the group the conflicting results of commercial trials noting the previous day's run at Weirton Steel had produced defect-free steel with a bath aluminum content of 5.2% and compared that to Nisshin's recommendation of 4.2%. Mr. Ayoub then asked Dr. Hirose if there was any magnesium in their alloy. Dr. Hirose then replied that there was magnesium present in small amounts. Dr. Hirose then pointed out that it was his first knowledge of a type I, type II alloy as pointed out in the table 21 of the #5 draft revision to the ASTM specification and noted that there is a need for a type III table for a mischmetal and magnesium alloy. At that point Dr. Goodwin noted that there is an allowance in the current GALFAN specification of 0.10 maximum magnesium and more information was necessary prior to making any changes, perhaps a better definition of GALFAN. Dr. Lynch noted that the 0.10 magnesium maximum level was put in the standard specification per a request from FICAL in France to allow for bath thickening. The maximum level of aluminum of 6.2% was also requested by FICAL. Mr. Leonard noted that ASTM only recognizes and will only change standards for commercially produced products not for experimental products. As there were no more comments on the subject, Dr. Goodwin then introduced Mr. Shimada from Sumitomo.

SUMITOMO CORROSION REPORT:

Mr. Shimada presented his report which is attached in its entirety to these minutes. The report concerned corrosion of a stainless steel GALFAN bath alloy transfer pipe. Such a pipe is normally used to transfer GALFAN alloy from a pre-melt pot to the main coating pot. The report details the corrosive attack of the GALFAN alloy on the stainless steel pipe. The group was reminded that the GALFAN alloy attacks the ferritic phase of stainless steels but does not readily attack the austenitic phase. Mr. Shimada concluded his report by noting the corrosion of the bath exchange pipe is caused by and accelerated by the high pre-heating temperature. If the GALFAN alloy exchange is repeated, the rate of corrosion is increased and is greater at higher temperatures, that is above 680°C. He recommended a 500°C maximum temperature to minimize corrosion.

At this point, Dr. Hirose then directed a statement to CRM personnel. He noted that nitrogen wiping is beneficial and asked if data could be supplied on surface tension and viscosity under air or nitrogen. He said he wanted to know what relation there is of surface tension to oxidation under air or nitrogen, and also asked what was the effect of nitrogen wiping on coating thickness. Mr. Renaux said that the aluminum oxide on the bath surface causes the ripples on the coated surface and nitrogen is used to prevent this oxidation. He said there was no significant similar data on surface tension. Dr.Hirose then asked what was the content of oxygen on the wire under the nitrogen shroud. Mr. Renaux replied that it was 600 parts per million oxygen with a 5% nitrogen atmosphere under a minus 30°C dew point condition. Dr. Goodwin invited more comments on nitrogen shrouding and nitrogen wiping and since there were no comments moved on to the research report by CRM.

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CRM RESEARCH REPORT:

Mr. Ayoub of CRM started his research report at 11:00 a.m. by reviewing the recommendations of the previous steering committee meeting. Those recommendations are attached to the minutes. Mr. Ayoub then reviewed the studies concerning the cathodic protection of bare edges. Several GALFAN samples with different characteristics were compared to galvanized samples and Aluzinc (Galvalume samples). The results of those tests are reprinted in detail attached to these minutes. Mr. Ayoub concluded his study on cathodic corrosion protection by saying that GALFAN normally shows an excellent behavior (except the one D sample in the marine site where steel gauge effect was extraordinary). The galvanized samples along with the Aluzinc samples in the severe marine sites were deeply attacked and corroded. He concluded that the Aluzinc provides a poor cathodic protection. Mr. Ayoub then reviewed the CRM studies concerning the ASTM specifications concerning aluminum and silicon contents of the GALFAN coatings. Those studies were fixed at 4.7 and 6.2% aluminum and at a maximum 150 parts per million (0.015%) silicon. Those different limit levels of aluminum and silicon were tested for two cooling rates, 5°C per second and 20°C per second in an outdoor exposure in an industrial site. The best behavior was seen at 5.2% aluminum only. The presence of silicon apparently did not have any benefit for the GALFAN coating however the results were only for one year exposure and it is recommended that a longer exposure be studied. Normal GALFAN without silicon addition shows the best behavior. A more complete summary of these results will be reported in progress report #17 which is currently under preparation. Mr. Ayoub then went into the wire program where industrial GALFAN coated wires were compared to industrial galvanized coated wires and in an outdoor exposure. Some of the tests were concerned with varying lead levels. He concluded that 1)the presence of lead in the GALFAN coating is deleterious; 2)the GALFAN single dip has shown evidence of inter-crystalline attack in a marine atmospheric exposure. (This inter-crystalline attack was not present in the humidity cabinet); 3)magnesium is a strong inhibitor of inter-crystalline corrosion generated by the lead; and 4)in galvanized coatings with a very low aluminum content (40 parts per million or 0.004%) the lead does not seem to have any influence. Those conclusions must be confirmed by outdoor exposure programs which have already been initiated. Mr. Ayoub finished this part of his report by summarizing their proposals for research continuation. (Also attached).

GREY PATINA:

Mr. Ayoub began by defining the grey patina and its detrimental cosmetic effects. CRM has applied several different treatments to unchromated GALFAN which were then exposed in the industrial site of Liege, Belgium and checked for darkening twice a month by light reflectance measurement. The two different treatments were a nickel electroless solution and a Brugal T3MG coating made by Procoat. It was concluded that the nickel electroless plating had no influence on dark grey patina formation, in fact, that treatment appears to be harmful because the surface after exposure is much more irregular with the presence of black spots. After only two months, the electroless nickel plate samples are quite grey. The treatment with the Brugal was very efficient with the surface remaining very bright even after ten months, however, the Brugal treatment is much more expensive then chemical chromation due to the high coating weight needed (2 to 5 grams per square meter). Mr. Ayoub then noted the case of GALFAN samples from the simulation equipment where the exit and complete cooling are made under protective nitrogen atmosphere. Here the oxidation of aluminum on the surface is much less important then for industrial sheets cooled in normal atmosphere. He said the mechanism of dark patina formation is modified and the surface is quite grey after only eight months of exposure. Here samples with a chromium-PVD coating have a very peculiar behavior showing an increase of reflectance which probably results from the oxidation of metallic chromium. After ten months the samples remain quite bright. Mr. Ayoub concluded by noting that the 1987 program foresees a GALFAN paintability study after dark patina formation along with other treatments such as 1)fluoride containing chromates for pickling the aluminum oxide layer, 2)an alkaline treatment prior to chromating, 3)electrolytic coatings such as chrome or nickel after pickling of the aluminum oxide layer.

RING TESTS:

Mr. Ayoub began this section by defining the ring tests. IN this case, it is used to evaluate the lubricant behavior of GALFAN coatings with respect to galvanized coatings. For this test cyclindrical samples with a hole of fixed diameter are compressed at room temperature at a deformation speed of 300 millimeters per second with no lubricant. The height of the sample is 10 millimeters, the inner-diameter is 15 millimeters and the outside diameter is 30 millimeters. Then different reductions between 10 and 40% are performed with the changes of height in inside diameter measured and related to the initial values. An increase or very slight decrease of inside diameter indicates a good lubricant property or a low friction shear factor whereas a strong decrease will indicate poor lubricant properties (i.e. the high friction shear factor). The first series of trials were made in 1986. The galvanized samples were prepared under batch galvanizing conditions using pure zinc resulting in a coating thickness of approximately 60 microns. The GALFAN samples were coated with the electro-fluxing process with a thickness of approximately 20 microns (just under a GF60 coating weight). The tests showed that the GALFAN exhibited a slightly higher friction factor than the galvanized steel. That behavior was related to the pulling up of some zinc particles playing the role of lubricant. In 1987 tests were performed for GALFAN and galvanized samples of an equal coating thickness of about 20 microns. In this case, the lubricant behavior of GALFAN and galvanized samples of equal coating thickness are quite similar and their friction shear factor is approximately 0.3 to 0.4.

Mr. Hodds of Stelco then asked Mr. Ayoub if there was any correlation with respect to the varying aluminum contents and the effect of tension bend cracking normally seen in roll forming. Mr. Ayoub replied that there was no data available and noted that it was a good idea for further study. Mr. Leonard then raised the question as to whether the galvanized material in the ring test was minimum spangle or regular spangle. Mr. Ayoub noted that it was batch galvanized and slow cooled.

At this point, Dr. Goodwin asked if there were any questions from the group to Mr. Ayoub. Mr. Austin Matthews of British Steel then noted that there seems to still be a conflict on aluminum contents that have been previously discussed all morning. Dr. Hirose then raised the point that magnesium improves GALFAN performance in that magnesium forms insoluble corrosion products. He noted that attention should be paid to the performance of those corrosion products which he referred to as "sticky" as compared to "loose" products. Dr. Hirose then reiterated his point that a type III table should be included in the ASTM specification. Mr. Goodwin interceded to note that corrosion products are either soluble or insoluble. To check the weight loss they are pickled or stripped off during corrosion tests. Mr. Ayoub then pointed out that he has studied Galvalume and has found that after one year in marine exposure the Galvalume zinc rich phase is totally corroded implying the loss of cathodic protection. He also pointed out that studies will be initiated to study the phenomenon in Galvalume that shows a underlayer corrosion at the intermetallic layer which lifts the coating off. It is not definite but it is possible there is an iron oxide at this intermetallic layer where there is some cathodic protection of the base metal by the intermetallic layer. Dr. Goodwin noted that there are conflicting results in which the variance and corrosion protection shows probably due to different environments such as the wet environment in Belgium compared to the dry environment in Australia. Mr. Matthews then asked if the Butler test had been applied for GALFAN coatings. Dr. Goodwin replied similar testings but not Butler testing had been done. The data at this time was not available and the closest simulation was the Volvo cycling tests. He felt that it was a good suggestion for further testing. Mr. Matthews concurred and pointed out that such testing should be done. Since there were no more questions or comments Dr. Goodwin then introduced Mr. Roman who gave the presentation by Hoesch Steel.

HOESCH STAHL PRESENTATION:

Mr. Roman summarized the Hoesch Stahl presentation entitled "Prospects For Zinc Coated Sheet Steel In Germany With A Special View Of GALFAN." The paper is reprinted in its entirety attached to these minutes.

RESEARCH RESULTS OF LICENSEES:

The meeting reconvened immediately after lunch and Mr. Bob Goodhart from Weirton Steel began his presentation by answering a question from the previous day's mill tour. He said that there had been no tension bending tests on non-skin rolled or skin rolled GALFAN coated sheet. The question had been raised at the previous days luncheon. Mr. Goodhart then gave his presentation on the performance of passivated GALFAN sheet. His report is attached to these minutes. Weirton Steel has sampled the commercial production of chemically treated GALFAN directly off the line after subsequent skin rolling. The test samples were then measured to determine the chem-treat level and subsequently tested to measure resistance to white rusting using the stack test. The chemical treatment system used by Weirton is a OKEMCOAT F1 which is a patented product produced by Oakite Products. It is a chromate-based conversion coating normally applied by spray plus squeegee rolls. It is the same system used for hot dip galvanized and GALFAN. The normal range of chromate treatment should be 3 to 6 micrograms per square inch. The test normally used for chemical performance is the stack test wherein at least three panels one foot square are cut of each sample lot. Those panels are stacked after having water sprayed on them. A weight is then applied and the samples are let to stand at room temperature for five days. This constitutes one cycle. There is then an evaluation and a rewetting after each cycle. The test is terminated when any one panel from any set has at least 10% white rust. To pass production materials must survive two cycles. The results of Weirton's stack testing are as follows: 1)The chemical treatment levels off the line varied from 3.3 to 5.9 micrograms per square inch which is similar to that found on hot dip galvanize; 2)Skin rolling reduced the chemical treatment level by as much as 67%, therefore skin rolling after chemical treatment reduces the corrosion resistance due to the reduction of chem-treat level; 3)Stack test cycles to 10% white rust were proportional to chem-treat level (i.e. the lower the chem-treat level the fewer cycles the samples survived and the higher the chem-treat level the more cycles the samples survived); 4)The resistance to white rusting exceeded minimum requirements when chem-treat levels were in the normal range. Weirton also performed Kesternich testing of unpainted GALFAN. They compared their GALFAN to bare hot dip galvanize and bare Galvalume. The samples were rated by cycles to initial red rust and then cycles to "heavy failure". The test results for cycles to initial variances 5% red rust were that GALFAN and Galvalume had similar results and galvanize had lesser results. The results for cycles to "heavy failure" were that Galvalume performed the best, GALFAN was next, followed by galvanize.

WEIRTON REPORT ON SPOT WELDING TRIALS:

Mr. Ed Adamczyk of Weirton Steel then reported on the spot weldability of GALFAN. That report data is also attached to the minutes. Mr. Adamczyk began by noting that the electrode life test must conform to the Ford BA-13-1 specification. Weirton Steel tested four materials. Two samples at a gauge of 0.032 inches, one each of GF30 and GF45; two other samples of experimental non-commercial gauge of steel at 0.036 inches, one each of GF30 and GF45. It was noted that the thicker materials needs a longer weld time and a higher weld force. The initial results with a one quarter inch weld tip diameter on 0.032 inch GF30 material yielded a maximum electrode life of 1500 welds. The 0.036 inch GF30 material yielded an electrode life of 1750 welds, both below the minimum Ford level of 2000. Weirton Steel then made the following changes in order to attempt longer tip life. 1)the use of a dispersion strengthened ore hard (Glidcop) electrode, 2)a change in the excluded angle of the electrode, 3)a change in the electrode tip diameters, 4)an increase and decrease in the weld time, 5)increases and decreases in the weld force, and 6) the addition of upsloping to the weld schedule. Mr. Adamczyk made it quite clear that the first five changes had all negative results in the electrode tip life. As a matter of fact, some of the results were worse than the original tests. The sixth change which was the use of upsloping yielded dramatically positive results. For example, on the 0.032 inch GF30 samples there was an electrode tip life of 3000 welds. On the material that was 0.036 inch GF30 there was a life of 2500 welds. Further on the 0.036 inch GF45 material there was 2250 welds. On the material that was 0.032 inch GF45 they achieved 2500 welds and on retesting achieved 5500 welds. Weirton Steel started with a nine cycle upslope area. Mr. Adamczyk made it quite clear that the use of the upsloping is the key to longer electrode tip life. Mr. Adamczyk then quickly summarized the testing as follows: 1)the use of the glid-cop dispersion strengthened electrode tip was negative. 2)A 30° instead of 45° excluded angle yielded negative results. 3)The increased tip diameter from 0.25 to 0.31 inches had a negative effect. 4)The increased weld time had a negative effect. 5)The increased weld force had a negative effect. 6)The use of the increased upsloping had the positive effect.

Mr. Hodds then asked if the auto companies knew of these test results. Mr. Adamczyk replied no, the tests had just been completed prior to the meeting. Mr. Matthews commented on the use of robotics, stating that there is little or nor flexibility of weld equipment and asked for comments on that.

Mr. Adamczyk replied that there were no studies done at Weirton using robotic equipment. Dr. Goodwin then commented that there were ongoing studies at MIT regarding the use of a spherical tip in conjunction with upsloping. He noted that a spherical tip overcomes the misalignment problem commonly seen with robotic welding equipment. At this time the studies showed much promise. Dr. Kim of Inland Steel asked about the uniformity of the coating used in the Weirton testing. Mr. Adamczyk replied that it was in a range of plus or minus 6 to 7%. Mr. Hodds asked if the retest procedure could be clarified. Mr. Adamczyk defined the retest as the same process variaoles, the same material, with the only change being fresh weld tips. A question was asked whether the material Weirton tested was skin rolled or not. Mr. Adamczyk replied that it was. Dr. Lynch then directed a question to Mr. Matthews regarding weld tip life of galvanized material used in robotics equipment. Mr. Matthews replied that there was no practical "real life" data and that galvanized material (G90) welded with robotic equipment currently is a problem in that there is a frequent need for tip redressing. There is not enough volume in the United Kingdom i.e. the number of cars welded, to give good data. Dr. Lynch added that Thyssen results were three years old, which yielded 2700 welds with adjustments for GALFAN. Dr. Hirose then asked about the secondary weld current used. Mr. Adamczyk replied that it was between 12 and 14 kiloamps. As there were no more questions or comments, Mr. Paul DePaul of Weirton Steel presented his report on paintability of GALFAN.

WEIRTON REPORT ON PERFORMANCE OF PRE-TREATMENTS AND PAINTS ON COIL COATED GALFAN:

Mr. DePaul presented his report on paintability of GALFAN coated sheet. This report is included with these minutes. He started out summarizing that GALFAN makes an excellent substrate for painted product. If properly pre-treated with the proper paint system it is an excellent product for pre-painting or post-painting. Mr. DePaul then reviewed in detail various pre-treatments, primers, and topcoats used for GALFAN in the Weirton tests. The best pre-treatment was the Parker B-1421, a zinc phosphate high nickel fine grain pre-treatment. The best primers in terms of overall performance were the epoxies and urethanes. Mr. DePaul added that various conventional topcoats applied over properly primed GALFAN have been evaluated, both in conventional thin film thicknesses and thick film thicknesses. Excellent performance results are being obtained. He quickly listed those topcoats. They are polyester, silicon polyester, ceramic pigmented silicon polyester, fluorocarbon, plastisol, ceramic pigmented plastisol, urethane, and water based. Mr. DePaul noted that coil coating of GALFAN can be performed using the standard paint system currently being employed on all conventional hot dip and electro-galvanize. This includes pre-treatments, primers, and topcoats which are currently being used on conventional galvanized material. He also said a comprehensive paint system evaluation of GALFAN was conducted involving all of the major North American paint companies that currently supply the coil coating industry. This comprehensive evaluation encompassed various pre-treatments, primers, and topcoats. Mr. DePaul reiterated that GALFAN, when properly pre-treated, provides an excellent base for post-paint and pre-paint systems and that the excellent formability of the GALFAN coating in combination with a flexible paint system provides an added opportunity for previously prohibitive pre-painted applications. Mr. DePaul then reviewed the types of testing performed on coil coated GALFAN. These tests concluded the 1000 hour salt spray test according to ASTM B117, the 1000 hours at 100% relative humidity according to ASTM D2247, the 1000 hour plus 240 hours Cleveland Condensing Humidity test, the Kesternich test, a detergent resistant test, along with flexibility and adhesion tests. In general, the GALFAN performed as well as galvanized or better and better than Galvalume at all times. GALFAN usually showed better edge creep resistance, better scribe creep resistance, and better cathodic sacrificial protection. Mr. DePaul then noted that post-painting was applicable to GALFAN in that post-paint systems currently in use on conventional galvanized can also be used on GALFAN. This would include such paint systems as acrylics, alkyds, and polyesters. Mr.

DePaul then finished up by noting that E-coat systems for GALFAN are currently being evaluated and there are no results at this time. At this point, Mr. Matthews raised the question if there was any information on passivation for E-coat systems. Mr. DePaul replied that there was none, that the tests were just starting. Dr. Lynch then asked if there was any input from the paint companies regarding such items as warranties. Mr. DePaul noted that there was, and the paint companies hold a positive attitude for coil coated GALFAN. At that point, there were no more questions or comments so Dr. Goodwin introduced Ms. Lisa Roudabush from the USS Division of USX Corporation.

USX REPORT ON CORROSION TEST RESULTS ON BARE AND PRE-PAINTED GALFAN

Ms. Roudabush reviewed in detail the results of the corrosion performance of GALFAN, galvanize, and Galvalume in accelerated and long term tests and also the results of some formability and weld test results. The material used in the corrosion performance test was obtained from Europe from CRM Pilot Line Trial Materials. The minimum spangle material was of a coating weight of 370 grams per square meter and the regular spangle materials was also 370 grams per square meter. Ms. Roudabush noted that there was a tin contamination in the trial material coating. Ms. Roudabush compared the corrosion results of their salt spray tests. The GALFAN material at 370 grams per square meter performed at a rate two and one-half times better than the normal galvanized material. The Galvalume material at 183 grams per square meter performed at a rate two times better than the GALFAN material. She summarized her Kesternich test results by saying that GALFAN was two to three times better than galvanized and Galvalume had similar results to the GALFAN. She noted that when coating thickness losses were measured GALFAN rated intermediate between galvanized and Galvalume where galvanized lost the most and Galvalume lost the least. Ms. Roudabush summarized the test results of their second series of tests using GALFAN material from Ziegler's industrial trial. The exposure sites were marine at Kure Beach in North Carolina and an industrial site in Monroeville, Pennsylvania. She noted that Galvalume and GALFAN were performing similarly. The Galvalume showed some minor spotting of red rust.

Ms. Roudabush then moved on to her weld test results. The USX weld testing was also performed to the Ford specification BA-13-1. Ms. Roudabush reported a weld tip life on the standard electrode of 500 to 600 welds and when an oversized electrode was used only several hundred welds could be achieved. This was far below the 2000 minimum speficied by Ford. She concluded that GALFAN yielded unsatisfactory weld results.

Ms. Roudabush then reported on the formability of GALFAN as compared to galvanized and Galvalume. She noted that the formability of GALFAN was generally good with no evidence of crazing or cracking. The microhardness study of the coatings was reviewed with the following results. Galvanize had the softest results but she did note that the outer layer of zinc was very soft, the intermetallic layer was harder and was the basis where cracks initiated. The Galvalume had the hardest microhardness results with GALFAN being in between galvanize and Galvalume. Ms. Roudabush noted that a post-annealing treatment of Galvalume homogenizes the coating and lowers the hardness. Ms. Roudabush reiterated that although the galvanize had the softest results the hard alloy layer cracks badly. The Galvalume cracks, but those cracks do not extend into the outer layer that is exposed to atmosphere. They are confined to the intermetallic layer. The post box annealing treatment of Galvalume improves those crack results. The Weirton GALFAN that USX tested to show no evidence of cracking.

Ms. Roudabush concluded by noting that GALFAN exhibits excellent coating ductility. GALFAN corrosion protection is intermediate between galvanized and Galvalume. The weldability of GALFAN was poor and the paint performance was equal to or better than galvanize.

Mr. Celestin then asked if flat or formed panels were used on the corrosion tests. Ms. Roudabush replied that the samples were flat. Then a representative from Stelco commented on the test results showing a high iron content in the GALFAN coating. Ms. Roudabush commented that it was possibly due to the effect of the alloy layer or some inclusions of solid precipitations in the GALFAN alloy analysis. Mr. Hodds asked if there were any tension bend results on painted product. Ms. Roudabush replied that there were no results however testing was commencing. Mr. Ayoub of CRM commented on the differences in corrosion test results for the Galvalume, referring back to his own test results. Mr. Sheehan of USX stated that although Galvalume may be corroding, those corrosion products of the Galvalume coating are protective and he referred back to Dr. Hirose's comment from the morning concerning the "sticky" non-soluble corrosion products. Dr. Goodwin then closed the discussion by noting the differences between the two research results and commented that perhaps those are just the difference between the lab and the real world.

BRITISH STEEL RESEARCH REPORT

Mr. Austin Matthews presented the British Steel Research summary. He stated that a new series of exposure tests utilizing GALFAN from Weirton Steel had been commenced. The exposure sites were severe marine, coastal, rural, industrial, and estuarine. He also noted that many tests were being performed on the exposure of leaded, unleaded, and alcohol enhanced fuels to GALFAN, with and without water mixed in. Mr. Belisle of Noranda asked if British Steel was looking at the phase separation of the fuel and its resultant exposure to GALFAN. Mr. Matthews replied that British Steel was looking at the total immersion of GALFAN in the fuel.

RASMET ZINQUENCH TRIAL

Mr. Sippola of RASMET presented his research paper on the Zinquench process. A copy of the report is attached to the minutes. After the report, Dr. Goodwin reiterated some of the technical aspects of the report.

MANHATTAN COLLEGE RESEARCH WORK:

As there were no further comments, Dr. Lynch then seized the opportunity to notify the attendees of ongoing work in Manhattan College concerning an oil modification for longer protection against white rust. Dr. Max Kronstein of Manhattan College is currently developing an oil additive which gives oil a higher affinity to adhere to a coated surface. The attachment to the minutes gives the pertinent information for contacting the proper personnel if any interest in shown.

CLOSING COMMENTS

Dr. Goodwin informed the group that ILZRO was working with Hoesch, Phenix, Thyssen and Sumitomo in a cooperative production trial effort to determine line conditions for the best surface appearance and the elimination of surface defects.

Dr. Goodwin also pointed out that General Motors has experienced poor weld performance on galvanize due to heavy coatings, due in part to the installation of the robotic equipment. This has resulted in the issuance of a GM specification labeled GM 6185M, which now imposes a coating weight maximum along with a minimum. Dr. Goodwin noted that ILZRO would like to prepare a GALFAN data sheet regarding coating weight minimums and maximums for informational purposes. He added that in order to help produce the aforementioned data sheet, he would like to know what companies present could produce hot dip coatings in the following ranges per the General Motors specification: 70-120 grams per square meter, 90-150 grams per square meter, 95-160 grams per square meter, and 20-60 grams per square meter. At that point, Mr. Leonard of USX replied that in his opinion the previously mentioned coating weight ranges should be within the reach of all North American hot dip galvanize producers.

Mr. Matthews then asked of the group if there was any corrosion data for GALFAN that was produced using a Heurtey minimum spangle treatment. Mr. Romain then noted that the corrosion resistance of the GALFAN coated sheet produced by the Heurtey minimizing apparatus was less than that of a GALFAN minimized spangle surface produced with a fast cooling apparatus. The Heurtey process yields more of a cosmetic min-spangle as opposed to the fast cool min-spangle. Dr. Lynch then noted that zinc particles on the surface of a hot dip sheet produced with the Heurtey minimizing process are not fully dissolved, resulting in an unusual structure which warrants further study. Dr. Goodwin then closed the meeting by mentioning that the next Licensees meeting may be held in France next fall around the end of October.

MINUTES OF THE TENTH GALFAN LICENSEES MEETING

MARKETING SESSION

Held At

The Pittsburgh Hilton
Pittsburgh, PA, U.S.A.
on
May 21, 1987

INTRODUCTION:

Dr. Goodwin first welcomed everyone back for the second day of the licensees meeting and also welcomed [illegible] attendees. The attendance roster was circulated for those who [illegible] present the previous day. Dr. Lynch then welcomed everyone and [illegible] the proceedings from the previous days meeting and [illegible] agenda.

Dr. Goodwin then reviewed [illegible] of the information presented the previous day during the Research Sessions concerning formability, paintability, and corrosion resistance. He referred to the work being done on the ASTM specification, heavy gauge material using silicon additions to prevent intermetallic growth, the work being done on grey patina formation referring to nitrogen [illegible] and fast cooling, the welding results where he commented on the [illegible] developing, paint work where he commented that GALFAN [illegible] different paint systems, and then he noted the work being done on Cook-Norteman Flux Lines and mentioned the six companies that have formed a research consortium with ILZRO. Those six companies are Wheeling-Pittsburgh, Empire-Detroit Division of Cyclops Corporation, LTV, Southwestern Pipe, H.H. Robertson, and Nippon Denro. Dr. Goodwin then concluded by introducing Mr. Roman who presented the report on GALFAN patents and trademarks.

GALFAN PATENT AND TRADEMARK ESTATE

Mr. Roman presented the report on the GALFAN patent and trademark estate which is reprinted in its entirety and attached to these minutes. He noted that the newest additions to the patent and trademark estate as listed below:

PATENTS (NEW)

COUNTRY	FILING DATE	SERIAL NO.	PATENT NO.	ISSUE DATE
Australia	03-18-81	70796/81	544,400	10-21-85
European (EPC)		81-301054.7*	0048270	08-14-85
Finland	11-20-81	813,715	70254	09-15-86
New Zealand	01-14-82	199,491	199,491	04-09-86

*France, West Germany, Luxembourg, Sweden, Switzerland, Liechtenstein, United Kingdom, Austria, and The Netherlands.

REGISTERED TRADEMARKS (NEW)

COUNTRY	FILING DATE	SERIAL NO.	TRADEMARK REGISTRATION NO.	ISSUE DATE
U.S.A.	11-01-85	73/566,270	1,414,721	10-28-86
Canada	07-28-81	473,239	313,867	04-03-87
New Zealand	01-10-84	150-709	150,709	10-08-86
Finland	07-09-84	235/84	92,853	06-05-85
South Africa	01-10-84	84/0191	84/0191	05-29-85
Transkei	03-24-84	84/0183	84-0183	05-29-85

At that point, Dr. Hirose questioned the status of the patent in Japan. He noted that such a process in Japan can be very lengthy and wondered if and when a patent would be issued. Dr. Goodwin and Mr. Roman both replied that the patent in Japan is still pending. The status would be checked upon their return to the ILZRO offices in North Carolina (Since that return, the patent has been checked with the legal offices and there is no change on status.)

Dr. Goodwin then took the opportunity to welcome the newest GALFAN Process Licensee: Nippon Denro Ispat, the thirty-fifth licensee. They had signed an agreement that morning, May 21, 1987. At that point, Dr. Goodwin passed the chairmanship to Dr. Lynch.

MARKETING SESSION:

Dr. Lynch began the Market Session by passing out copies of the leaflet entitled "How Does GALFAN Compare" of which a copy is attached to these minutes. Dr. Lynch then related that the data sheet compares GALFAN to hot dip galvanized, electro-galvanize, galvanneal, Galvalume, aluminized, and zincrometal. The comparisons include product performance and pricing. Dr. Lynch then highlighted the features of the GALFAN product such as 1)the increased formability for stamping and roll forming; the coating stays with the base metal. There are fewer microcracks and it has formability similar to that of electro-galvanize; 2)greater corrosion resistance: GALFAN corrosion resistance is greater than galvanize - two to three times that of galvanize along with the full sacrificial protection. He noted that data the previous day was presented to back that point up, and also noted that among all that data generated by many companies is very useful for the marketing aspect; 3)the improved painted performance: Dr. Lynch reviewed the positive results presented the previous day on painted GALFAN performance and noted that painted galvanize is good in its niche, painted Galvalume is good in its niche, but pointed out and highlighted that GALFAN performance is very good - it deformed with the paint, resists corrosion, resists edge creep, resists paint liftoff. Those claims are backed up by laboratory tests and "real world" tests. Dr. Lynch wrapped up the third category by noting that GALFAN provides an opportunity for hot dip coatings in difficult and previously unpenetrated markets. At that point Dr. Lynch reviewed the handout in detail with respect to the other coatings while highlighting GALFAN. He noted that there was no sum at the bottom and pointed out that not all the features are considerations important to any one individual application. He emphasized that the chart was put together as an overall survey.

Mr. Matthews of British Steel [illegible] Dr. Lynch on putting together the document. He [illegible] summations at the bottom of the columns, not taking into consideration aluminized coatings and zzincrometal. Mr. Matthews feels [illegible] Dr. Lynch replied the sum can be used but again [illegible] chart is to be a overall survey and not to rate [illegible] aspects.

It was brought to the group's attention [illegible] GALFAN appears to be the best all-around coating. [illegible]

Dr. Hirose [illegible] of the listed coatings. He asked if the [illegible] were available for GALFAN, Galv[illegible] Dr. Lynch replied in his position he could [illegible] because he didn't have that information but he [illegible] considerations for the different coatings (e.g. the GALFAN [illegible] but lighter coatings may be required, Galv[illegible] costs, and different line considerations such [illegible]). Dr. Lynch pointed out that essentially the GALFAN, Galv[illegible] are of the same general costs and then asked Dr. Hirose [illegible] on that matter. Dr. Hirose agreed that the selling [illegible] but the production costs are not the same. [illegible] agreed with Dr. Lynch that the costs can [illegible] various considerations.

Mr. DePaul [illegible] wondering if zinc nickel coatings should [illegible] Dr. Lynch replied that it may be necessary to do [illegible] be necessary to do so for electrolytic zinc [illegible] coatings.

The question was raised [illegible] put the chart together, end users or producers. Dr. Lynch replied that [illegible] producers and end users as could be contacted.

Mr. Alfano of [illegible] consistency of GALFAN's surface appearance may pull [illegible] GALFAN's market [illegible] down and noted that the product needs more consistency and [illegible] in the marketplace.

Mr. Takasaki asked [illegible] considerations. He asked what the trends were in the United States. He referred to the Hoesch paper and asked if the coatings were getting thinner or thicker. Dr. Lynch replied that these considerations [illegible] in the U.S. and there is no clear answer to the question.

GALFAN APPLICATIONS:

Dr. Lynch prefaced his presentation by noting that GALFAN sheet, tube, and wire could be applied to the construction industry, automotive industry, appliance industry, agricultural, and fencing industry. He then went into great detail listing the various applications and end uses.

CONSTRUCTION APPLICATIONS:

Dr. Lynch started his presentation noting that the Japanese are having great success using painted GALFAN for the construction industry, mainly roofing and siding. The excellent corrosion resistance of GALFAN at formed or bent areas along with the corrosion resistance at the cut edges combined with its excellent paint adherence is a prime consideration for the use of making the necessary profiles. Dr. Lynch then noted that there was much product literature available on the tables in the meeting room. He continued by noting the various end uses available for GALFAN products in the construction industry. He continued by listing several examples such as: door frame channels, which utilize tight bends in highly deformed areas; window frames which are regaining the market previously lost to plastics. Here painted GALFAN is highly resistant to the ultra-violet degradation that plastics are vulnerable to. Also building product accessories such as down spouts and gutters, parts that may have highly deformed profiles and require corrosion resistance in the bare or painted state. Garage doors previously made of wood are now being made of pre-painted GALFAN and there is also roof decking which is a popular application in Germany. Dr. Lynch then showed more slides exhibiting complex profiles for which GALFAN is the material of choice. Dr. Lynch then noted that GALFAN is performing very well in burial tests which means that GALFAN may be used for culvert applications in which the sheet is deformed and buried. Here GALFAN would be competing with concrete.

APPLIANCE APPLICATIONS:

Dr. Lynch started this discussion by noting that appliance manufacturers are looking to improve their manufacturing process and the performance of their products. He then referred to the Speed Queen detergent test where GALFAN sheet is showing good results. Briefly he noted the test measures the loss of coating over time. Galvanized material usually lasted 200 to 300 hours before showing 5 to 10% red rust. GALFAN showed two to three times better performance than the galvanized material. Galvalume showed two to three times better performance than the GALFAN. However, Dr. Lynch noted that the Galvalume is not as formable as GALFAN. He noted that this is the big point that appliance manufacturers like about GALFAN. It has the improved corrosion resistance with the high formability. Here heavy GALFAN coatings can give an improved performance and a longer product life. Dr. Lynch then showed various slides showing such parts as motor mounts, fans, air conditioner drip pans, applications where there is a hot humid environment where GALFAN is performing well.

Dr. Lynch noted [illegible] GALFAN parts will surely grow pending Underwriters [illegible] certain parts. Underwriters Laboratories has [illegible] GALFAN equivalents as listed below:

[illegible] coating.
[illegible] coating.

Here the [illegible] lighter coating weight which will [illegible] lower coating weight. Dr. Lynch made [illegible] an independent unsolicited approval [illegible]

Pre-painted GALFAN [illegible] interest in that GALFAN usage could [illegible] currently used on many [illegible] corrosion resistance [illegible] savings over the [illegible] pre-painted GALFAN [illegible] and [illegible] in the [illegible] The use of [illegible] the hiding of a cut edge [illegible]

AGRICULTURAL [illegible]

[illegible] slide [illegible] [illegible] wires [illegible] [illegible] formability, and [illegible] the farm [illegible] as Triple Life fen[illegible] in the United Kingdom [illegible] in the United [illegible] of NSK Corporation where [illegible] posts. In France, [illegible] boats where it [illegible] is off-shore oil [illegible] companies for [illegible]

AUTOMOTIVE [illegible]

Dr. Lynch [illegible] by referring to the [illegible] by himself and Dr. [illegible] in the meeting room. He then [illegible] performed in Detroit and Buffalo [illegible] tested and compared for the percentage [illegible] and two years of exposure.

In the Detroit test where the panels were vertically mounted, GALFAN had a 9% coating weight change where galvanize had an 18% coating weight change. In Buffalo where the panels were mounted horizontally, GALFAN had a 3% coating weight change whereas galvanize had 36% change. Dr. Lynch noted that the automotive market requires formability and corrosion resistance. Here he referred to a Hoesch Steel test where GALFAN lasted twice as long as galvanize with one-third the coating weight by only showing slight white rust in the salt spray test, whereas the galvanize showed bad red rust.

Dr. Lynch noted the Ford Motor Company is now using GALFAN coated tubing for all transmission fluid cooling lines on all cars and light trucks manufactured since 1984 with automatic transmissions. This application of GALFAN coated tubing has taken the market from terne-coated tubing. Another Ford application was a GALFAN sheet interdeck panel for the Continental Mark VII which is an unexposed part in the trunk. Ford had problems previously with Armco Ultra-smooth material and NKK material, whereas GALFAN passed the formability test for this part the first time. Also all Ford Thunderbirds with the plastic fuel tanks will now use GALFAN coated sheet as a tank shield beginning in the 1989 model year. This part will protect the plastic fuel tank from road gravel and other road debris.

Dr. Lynch noted that GALFAN was advantageous in automotive applications because there is less or no zinc pickup in the dies which reduces the salvage and repair operations for the stamping process. He noted also that the Ford Taurus and Mercury Sables would have GALFAN floor pans if wide material was available for the application. In this case, GALFAN has been approved but is just not available. Dr. Lynch pointed out that GALFAN coated sheet will not be currently used for exposed panels on automobiles where electro-galvanize now has captured the market and is the accepted norm.

Dr. Lynch showed slides showing the use of GALFAN coated wire for automotive applications. Here he noted such parts as headlights springs, door lock wires, and certain brackets and then referred to the paper entitled "GALFAN Coated Steel for Upgraded Product Performance" for these applications.

REGIONAL MARKETING PRESENTATIONS:

After a short break, Dr. Lynch asked each representative from each company present to give a marketing presentation for their specific market. He noted that this is a different new perspective over his own presentation. He then asked that each presentation include tonnage figures. If possible, those figures should include cumulative shipments through 1986 and planned production for 1987 and the ongoing status of GALFAN at that company.

ZIEGLER MARKETING PRESENTATION:

Mr. Maslet began his presentation by noting that GALFAN is produced by Ziegler in campaigns six times per year. He said that in 1986 they had produced 3,600 metric tons and they expect to produce the same tonnage for 1987 at 600 tons per campaign for six campaigns. Some of their applications are the use of drawing quality sheet for automotive air exchangers along with the production of GALFAN for coil coating for applications with severe profiles.

MAUBEUGE MARKETING PRESENTATION

Mr. Guy Durand of Maubeuge began his presentation by noting that Maubeuge produces GALFAN mostly in regular spangle and has produced 20,000 tons in three years through 1986. The majority of this material was in the size range of 0.5 to 2.0 millimeters. They produce structural and profiling quality sheet.

He noted that Maubeuge must adjust their wiping conditions to prevent certain surface defects. They also need to improve the base metal surface cleaning prior to dipping the strip in the GALFAN bath. They also feel it is very necessary to maintain the brightness of the coating for the end user.

Maubeuge does not anticipate any problems in the marketplace switching from galvanize to GALFAN. They feel there should be no price problem by balancing the lower coating weights with the higher alloy costs.

Maubeuge also produces minimized spangle temper-rolled GALFAN. They feel that GALFAN coated sheet is the substrate of the future for pre-painting but it is necessary to make it well and be consistent with the market price in order to do so. The process is low cost continuous and yields material witn excellent corrosion resistance and excellent formability with no cracking. They feel they can market the pre-painted sheet as an improved corrosion resistance sheet and may be able to apply specific warranties.

Dr. Lynch then asked Mr. Durand what coating weights were used. He replied that in the regular spangle application it is a GF 90. Mr. Belisle asked what tonnage was planned for 1987. Mr. Durand replied that there was no tonnage plan for 1987. Then Dr. Kim asked what min-spangle apparatus was used. Mr. Durand replied that they used a steam-DAP apparatus and that they did not like the Heurtey process.

BRITISH STEEL MARKETING PRESENTATION:

Mr. Austin Matthews presented the British Steel marketing report. He noted that no GALFAN has been produced yet at British Steel and there were no plans to produce any in 1987. He stated that it is a tough market to penetrate in the United Kingdom and British Steel currently has gone to Galvalume production. They do not want to produce GALFAN because they do not want to flood the market with several different types of coated sheet. They are still looking at GALFAN with "good market intelligence".

ZINC DEVELOPMENT ASSOCIATION MARKETING PRESENTATION

Mr. Matthews then gave the presentation for the ZDA in the United Kingdom. Mr. Matthews started by noting that: 1)The ZDA has sent out 600 brochures published by EZI (European Zinc Institute) and he has noted a 6% return response. 2)ZDA is promoting GALFAN to wire producers. (At this point, Dr. Goodwin noted that there are six different wire producers and they are moving on and developing the agricultural market at this point. Dr. Goodwin noted that British Ropes is using material produced at FICAL to produce 472 tons of GALFAN coated wire rope for TV towers in Denmark.) 3) Standardization: To sell a product in the United Kingdom, one needs certification. Mr. Mathews noted that GALFAN needs certification and specifications to penetrate the market. 4)Publicity - ZDA has sent GALFAN articles to trade journals as of April 1987. So far, as of the meeting in Pittsburgh, there was no response. 5)ZDA plans to produce the GALFAN publication for the United Kingdom based on material received.

Mr. Matthews emphasized the fact that to promote GALFAN, it should be segregated or differentiated from other products such as galvanize or Galvalume. Mr. Matthews then presented a slide listing the unique properties of galvanize, GALFAN, and Galvalume materials. Under galvanize was listed galvanic protection and its good track record in the market. Here Mr. Matthews emphasized strongly that there is nothing wrong with galvanize - it's a first class product. He noted that galvanize should not be put down to make room for GALFAN. Galvanize has its own place and will always have its own place in the market. Listed under GALFAN was its coating ductility and twice the corrosion resistance as galvanize, and under Galvalume he listed its corrosion resistance, three to four times the corrosion resistance of galvanize, and its excellent track record in the metal building industry. Again, he emphasized that each material had its own market niche, and he felt the main competition for GALFAN is plastic. He felt the methodology of fighting the competition should be GALFAN over plastics.

Mr. Matthews then showed what GALFAN must do to sell in the automotive industries. He listed three items of market strategy:

1) The importance of body in white competitiveness.

2) The stampings roll in the body in white system-low cost tooling effect.

3) The product development process in stamping strategy.

All three categories lean towards improving the total manufacturing costs. At this point, Mr. Raymond Sempels asked Mr. Matthews to clarify for the group what body in white meant. Mr. Matthews replied that the body in white is a shell of the car to be painted.

Mr. Matthews continued his presentation by noting that GALFAN will not be used on exposed automotive parts, but will be used or could be used on the unexposed highly-drawn parts. If it is to be used, it must be to reduce the total production cost of a part or certain parts because carmakers want cost effective material. He then emphasized that to be successful in the British market, GALFAN needs better weldability. He referred to his previous days questions on robotic welding at this point and asked if any work had been done on adhesive bonding. He had heard no comments about adhesive bonding in these meetings. Dr. Lynch asked Dr. Goodwin to clarify adhesive bonding for the group. Dr. Goodwin noted that there was an ongoing project sponsored by ILZRO through the Edison Welding Institute of Columbus, Ohio. They are working on joint design with the use of adhesive bonding agents. Five companies will be donating product for study. Those five companies and their products are:

1)US STEEL - two side electro-galvanize
2)INLAND Steel - galvanneal
3)ARMCO - Ultrasmooth HDG
4)CHRYSLER - Iron-Zinc Electro-galvanize
5)WEIRTON STEEL - GALFAN

Mr. Leonard asked if there was any current application for GALFAN in the United Kingdom. Mr. Matthews replied that there was not. There could be a market in construction and building profile products but he insisted there was no automotive market for GALFAN in the United Kingdom. Dr. Lynch asked if that could be due to the lack of availability of GALFAN. Mr. Matthews replied that that was somewhat true and GALFAN could have more market penetration if it was more agressively marketed. However, ZDA does not want to market GALFAN as such. At this point, Dr. Lynch wrapped up the presentation by summarizing that the United Kingdom has a market for GALFAN coated wire but little or no market for GALFAN sheet. He quickly reviewed Mr. Matthews' presentation noting that GALFAN coated steel needs to be marketed more agressively for automotive applications and should be marketed as a competitor to plastics.

Mr. Matthews wished that SIGMA Associates be acknowledged for providing him the flow diagram (copy attached) that he showed. The specific reference was: SAE International Congress, February 26, 1986, by Mr. Richard P. Hervey.

ENSIDESA MARKETING PRESENTATION:

Mr. Lastra noted that Ensidesa was not producing GALFAN, had not produced GALFAN, and had no planned production for GALFAN. He noted that they are currently producing galvanize and Galvalume and they see no market for GALFAN. They are currently still gathering information on GALFAN.

RAUTARUUKKI MARKETING PRESENTATION:

Mr. Pelkkikangas presented the Rautaruukki marketing report. He noted that there has been no production of GALFAN as of yet, however Rautaruukki has done extensive testing and they feel that possibly by March of 1988 they can be producing GALFAN. On their number one line, they have a 200,000 metric ton per year capacity for galvanize sheet. Their number two line for GALFAN has a 70,000 metric ton per year capacity. He noted that they have the capacity for Zinquench on their GALFAN line. He also noted that they would produce GALFAN in the coating weight ranges of 100 to 350 grams per square meter and that most of the market would be for pre-painted applications. He stated that market would be 80 to 90% of their GALFAN production. Dr. Lynch asked how much GALFAN would be produced on their number two line. Mr. Pelkkikangas replied that it would be dedicated to GALFAN production. Mr. Smith of Inland Steel asked what markets would Rautaruukki be pursuing. Mr. Pelkkikangas replied that it would only by the Finnish domestic market for mostly building products. Dr. Lynch then mentioned the publication of the paper entitled "Rautaruukki Goes For Zinquench" a copy of which is attached to these minutes.

EZI MARKETING PRESENTATION:

Mr. Raymond Sempels began his presentation by stating he wouldn't go into depth of applications since that was already covered by Dr. Lynch. He preferred to cover the zinc producers position on GALFAN. There are sixteen zinc producers in the European Zinc Institute. EZI does not promote the use of one specific coating but prefers to give guidance for the users. Mr. Sempels broke his presentation down to three main headings:

1) The Development of GALFAN - He noted that the development of GALFAN was influenced by the competitiveness of Galvalume which reduces the use of zinc down from 100% to 45%. He noted that GALFAN is a good product which is ready for promotion even though research is currently ongoing. He also noted that there are different situations in different countries referring to different markets for different materials. The EZI wanst to protect the zinc market from penetration by plastics and aliminum based coatings but thanks to unique properties of GALFAN not only is the zinc market protected but there are new applications for zinc coated steel that have not yet been fully developed.

2) The Research and Testing of GALFAN - This has lead to the distribution of samples for distribution to European countries for their own testing and evaluation. He noted that good test results have been seen in some countries and not good results in other countries. Mr. Sempels noted that EZI supports the development of GALFAN by contributing both to ILZRO and the GALFAN Technical Resource Center.

3) The Actual Active Promotion of GALFAN - He noted that the EZI wants to promote the best product for the best application and wants to use the GALFAN Technical Resource Center to coordinate that development. He felt that GALFAN should be promoted to the markets currently unaware of GALFAN and in doing so plans to sponsor a GALFAN planning seminar in Europe perhaps at the end of October. EZI also hopes to develop new markets for GALFAN such as in Eastern Europe.

Dr. Lynch then asked for any comments on Mr. Semples presentation. As there were none, he summarized that he was encouraged by the support and current work going on by producers and users of GALFAN.

Mr. Matthews expressed his interest in the EZI work on developing the Eastern European block market. He wondered if anyone intends to sell zinc or zinc alloys or ship any finished product to Eastern Europe. Mr. Semples replied that the intention was to inform those countries and any sales are of subsequent benefit to the seller. Mr. Matthew then said that he felt that the development of the Eastern European market will eventually harm the Western European market through subsidized exports to Western Europe. Dr. Goodwin then disagreed with Mr. Matthews. He felt that the Eastern European countries would develop the market for their own internal uses. Mr. Matthews then said that he was only making his comments as a marketing man.

Dr. Lynch then introduced the Weirton Steel representative, Mr. Andy Celestin, and again thanked him for the mill tour and their hospitality for the week.

<u>WEIRTON STEEL MARKETING PRESENTATION:</u>

Mr. Celestin opened by saying he had planned to present a sample of pre-painted woodgrain embossed garage door, however the samples has been lost and instead circulated a smaller sample. He noted that the sample was for the application to Haas Door, a very new customer of Weirton GALFAN sheet steel. He noted that Haas Door had selected Weirton GALFAN because nothing else had worked for them and that it was compatible with the polyurethane foam that would be used for insulation. Mr. Celestin noted that the market has expanded for this product, in fact, there is a large demand for which Weirton can't keep up with.

Mr. Celestin added that Weirton was studying adhesive bonding but had no results available for presentation yet.

Mr. Celestin pointed out that the mill tour of the 19th highlighted the 7th GALFAN Campaign for Weirton Steel. They now regularly produce GALFAN every eight weeks. The bulk of their market was for appliance, automotive, and construction applications. He noted that Weirton Steel did not want to rush GALFAN into the market and therefore, they "walked it" to the market. Weirton Steel felt that a cautious promotion as a value added product would be the best for its GALFAN. They prefer to promote it as a niche product with its own specialized market.

Weirton Steel produced 7,000 (short) tons of GALFAN sheet in 1986 and they plan to produce between 8,000 and 10,000 tons in 1987. They feel the market is growing tremendously and as the only sheet producer in North America they find themselves somewhat constrained due to the limited width constraints of their own line. For wide applications, they must import to maintain their hold on that specific market.

Mr. Celestin then showed various samples with an explanation for each. There was an outdoor electrical box which has now been UL approved. Then a washer mount leg, a large dryer drum for Speed Queen (for which they assisted in welding and they found that it does weld well). At this point, Dr. Lynch asked Mr. Celestin what kind of testing was done on the dryer drum. Mr. Celestin replied that corrosion testing was performed on the bare GALFAN whereas normally Speed Queen had done testing on coated material. The GALFAN coated material for the dryer drum passed with no stain and no darkening, in fact they had such good results that other washer and dryer applications are being looked at on a larger scale. Some more examples of GALFAN applications were a windshield motor housing, for which there is a 200,000 ton per year requirement. At this point, Mr. Celestin noted that the total potential for GALFAN tonnage for all heavily deformed automotive parts was approximately 20,000 to 24,000 tons per year. He continued by showing more samples such as a 150 ton per month requirement for rust proofing panel plugs. A rear-lit tachometer housing, which is first painted then heavily deformed. That specific part used to be formed and then painted. The new procedure represents a 40% savings for the manufacturer. Mr. Celestin then said that Weirton Steel was going after the Sears pre-painted refrigerator door panel which is currently made of painted cold roll, which is showing edge rust. He was confident that Weirton would win that market. He sees a large potential market in the painted roofing business. He noted that Galvalume is the proper material of choice for low slope bare roofings, but felt that increased sloped roofing which normally is a painted application would be a large market for GALFAN. Another possible market for GALFAN is garage door tracking. He summarized this presentation by saying that there are many opportunities in the large marketplace which have yet to open totally. Mr. Matthews of British Steel asked if Weirton was doing any culvert work. Mr. Celestin replied that they were not yet but they planned to because the current GALFAN line at Weirton cannot run heavy gauge. They expect to produce a second GALFAN line in the second quarter of 1988 which can produce material 48 inches wide at gauges up to .168 inches.

Mr. Matthews then asked if any related research work was being done at CRM. Dr. Goodwin replied that there was work being done on soil chemistries and that the work was not finished and was ongoing. Mr. Ayoub of CRM noted that some results were just in to CRM. He said they were testing rural soils and soil near a highway where there is much exposure to heavy winter salting. He noted that that type of soil was very agressive. Dr. Goodwin added that since the data was brand new, there are still a lot of interpretation and conclusions to be made.

Dr. Lynch pointed out to the group that the culvert market for GALFAN was difficult to penetrate in that there were few samples available for industry testing. He said that currently the culvert market is a 375,000 ton per year for galvanize, 17,000 tons per year for aluminized, and 7,000 ton per year for Galvalume. He felt that GALFAN could compete with concrete in this area. He said the corrugations were an ideal application for GALFAN sheet and its compatibility to be coated with asphalt was also a plus. The aluminized materials could take the market as they are reputed as being twice as good. Noting that, Dr. Lynch added when samples were available, the culvert makers will test them. He noted that such samples should be at least 28 inches wide, 16 gauge and possess a heavy GALFAN coating on the order of a G200 (2 ounce per square foot) coating. Dr. Goodwin also added that worldwide soil samples would be needed for chemical evaluation for related studies. Mr. Smith then asked why was the slope of a roof an issue for GALFAN/Galvalume applications. Mr. Celestin replied that customers prefer a painted product when the product can be seen as on a high slope roof. A low slope or flat roof is not normally visible from the street and therefore that's where Galvalume fits in its niche. However, the GALFAN painted product is performing better than Galvalume and that's where the application for high slope roofs comes in.

Dr. Lynch then asked Mr. Celestin how much GALFAN tonnage did he foresee "down the road". Mr. Celestin replied that for Weirton Steel the potential was for 12,000 tons per month.

GREGORY GALVANIZING MARKETING PRESENTATION:

Mr. Gimigliano started out by saying that Gregory Galvanizing started producing GALFAN in late 1985 and into 1986. They produced approximately 500 tons of GALFAN coated material in 1986, most for fence post application. Much of the fence post material is applied to Cyclone Fence Division of the USX Corporation.

In the latter part of 1986 Gregory Galvanizing encountered an operating technical problem unique to GALFAN alloy and unique for Gregory's line parameters. Due to the high temperature required for heating their hot roll material and their lack of ability to cool the strip going into the bath they were encountering a tremendous problem with iron dissolution in the alloy bath. As a result, they put a hold on GALFAN production. Information from ILZRO and CRM has been helpful to solve their problem. They feel they should be running GALFAN again by June or July of 1987. Dr. Goodwin asked them what tonnage could he predict for 1987. Mr. Gimigliano replied that those figures were unavailable and depended entirely on when the line could be restarted.

INLAND STEEL MARKETING PRESENTATION:

Mr. Jim Smith noted that Inland Steel was at the licensees meeting as an observer/spectator. Inland Steel is evaluating GALFAN and gathering information.

USS DIVISION OF USX CORPORATION MARKETING PRESENTATION:

Mr. Ralph Leonard noted that US Steel is currently evaluating GALFAN. US Steel is very interested in GALFAN due to its excellent formability characteristics and they are watching Weirton Steel's production runs of GALFAN. US Steel feels that it would be good for the pre-painted market however, they question the strategy of dedicating an entire hot dip line for the production of GALFAN. This relates to the problem of splitting time on one line between two products and the associated down time to make those switches.

Dr. Lynch noted that Jim Falciglia from American Flex Conduit had been present but did have to leave. He said they are considering the use of GALFAN strip for their armored conduit product. Dr. Lynch also noted that representatives from Bundy Tube were at the meeting but had to leave. They are a new GALFAN licensee in the tube market. One specialty of Bundy Tubing is a double walled brake tube.

INDIANA STEEL AND WIRE MARKETING PRESENTATION:

Mr. Phil Elser of Indiana Steel and Wire noted they are currently planning a pilot line production for GALFAN in the fourth quarter of 1987. They would produce high carbon strand wire much of which would be applied to chain link fencing. They anticipate the production of between 20 and 100 tons for 1987.

NORANDA MARKETING PRESENTATION:

Mr. Serge Belisle made the presentation on behalf of ARC Tube. He noted that ARC Tube is currently working for supplying Ford Motor Company with the previously mentioned transmission cooling line tubing. There are currently trials for similar material at General Motors. He estimated the tonnage to be approixmately 50 tons per month in 1987 but did not know the actual tonnage.

Dr. Lynch solicited but received no further comments from the zinc producers and went on to review Dr. Goodwin's flux consortium. He mentioned that the purpose for the consortium was to study and develop flux process on Cooke Nortemann lines for production of GALFAN sheet. Those six companies were:

- Empire-Detroit Steel Division
- LTV Steel Company
- Nippon Denro Company, Ltd.
- H.H. Robertson Company
- Southwestern Pipe, Inc.
- Wheeling-Pittsburgh Steel Corporation

Dr. Lynch also mentioned a company named Triangle PWC who expressed interest in GALFAN. They produce a product similar to that of American Flex Conduit. He then reviewed some of the available literature which was on the side for distribution to all attendees. He mentioned that the Zinc Institute was developing specific information for publicity purposes and then noted there was really no need for ILZRO or the Zinc Institute to maintain a sample bank of GALFAN as most consumers were going directly to GALFAN producers for samples. Dr. Lynch then introduced Gary Hook of New Zealand Steel.

NEW ZEALAND STEEL MARKETING PRESENTATION:

Mr. Hook started his presentation by noting that New Zealand Steel is the only sheet producer in New Zealand. He noted that over the past few years, New Zealand has imported approximately 300 tons of GALFAN material from various suppliers in different gauges, coating weights, and surface finishes. (Approximately one-third of that material has had to be rejected for various reasons such as white rust, edge damage, dross, bare patches, and pin holes, and uneven and low coating weights.) He continued by saying the majority of the usable material has gone into roll form feed or press tile feed for roofing and cladding manufacturer. Approximately one-half of that imported material was used in the pre-painted condition where both fabrication and end use monitoring have shown little or no difference when compared to standard galvanized substrates. He added that New Zealand Steel has asked that the GALFAN material be processed and put into use as much as possible along with conventional galvanize so that any variations can be noted. So far all feedback to date has shown no adverse affect in GALFAN's application when compared to normal galvanize. Mr. Hook noted that fabrication is causing concern in the areas of roll forming and joining. He said that the GALFAN material apparently required more lubrication during the roll forming. The extra lubrication would be a higher cost and also could be a safety hazard with slippery sheets. There also appeared to be more metal pickup for GALFAN than galvanize causing lengthy cleaning down times. Mr. Hook then noted that joining by the use of soldering is proving successful with certain soldering fluxes, however there is concern with more materials costs and extra degree of time and skill required to complete joints when compared to galvanize material.

Mr. Hook made the following general comments which include:

1) There is a proliferation of extra products in the marketplace in New Zealand.

2) There is a need for standardization on the coating weights or coating thicknesses.

3) The cost involved for GALFAN - Comparable to Galvanize and Galvalume.

New Zealand Steel has produced and published a coating bulletin with the expressed purpose of explaining the evaluation of GALFAN. He said to date this has proved successful and out of nearly one hundred companies visited nearly half are actively assisting New Zealand Steel in the project. A copy of that bulletin is attached to these minutes.

New Zealand Steel has recently expanded its evaluation to include the more diverse end uses available throughout the general sheet metal and fabrication industries. Some of these areas include building products construction, partitioning, horticultural structures, stocking crates, switch gear cabinets, heat ducting, cable trays, and culverts. Products such as those listed above have been fabricated and in some cases are now out on location. A follow-up evaluation will be carried out throughout 1987. He added that in New Zealand GALFAN material is being offered to all comers for trial evaluation.

New Zealand Steel expects to produce approximately 200 to 300 metric tons of GALFAN coated sheet, probably in the fourth quarter of calendar 1987. This production will commence after certain engineering improvements are made on their twenty-year old galvanizing line. They expect to improve their strip cleaning capability and update pot equipment for GALFAN.

Mr. Matthews asked Mr. Hook to expound on the problem of roll forming and the use of additional lubricants. Mr. Hook replied that was not much experience with zincalume and therefore had no comparable information. Mr. Matthews asked Mr. Hook then to explain why they would go for GALFAN rather than other hot dip coatings. Mr. Hook replied that due to the proximity of the ocean to all New Zealand locations they need the unique properties of GALFAN for pre-painted applications. Mr. Gimigliano commented that they had roll formed 200,000 feet of GALFAN coated steel with no problems whatsoever concerning pickup. He noted that they were roll forming heavy gauge hot roll material with a 2 ounce GF200 coating. Mr. Hook noted that the steel roll formed in New Zealand was of lighter gauge and a GF90 coating weight. Mr. Durand noted that a roll forming equipment can be adjusted and the use of hard chrome plating on the roll forming equipment will allow GALFAN to be roll formed without problems.

Dr. Lynch asked if Nippon Denro Ispat, the newest GALFAN licensee was going to present any kind of marketing data. Dr. Cole of ILZRO noted that the Nippon Denro Ispat representatives had left and that there was no marketing or production information available at this time.

KAWASAKI STEEL MARKETING PRESENTATION:

Mr. Oishi started the presentation by noting that Kawasaki had produced 21,000 metric tons of GALFAN coated product from 1984 through 1986. In 1987 they planned to produce 15,000 metric tons. Their applications are for the construction roofing and siding industry, mostly in the pre-painted condition. The application of bare GALFAN is used for refrigerators and washing machines.

They are concerned with the problem of grey patina and they are further investigating that phenomenon and they feel once the problem is solved they can expand their marketing of bare GALFAN. He added that they only market their GALFAN product in Japan. Dr. Lynch asked if there was any production for the automotive industry. The reply was that Kawasaki was only just starting to produce GALFAN for the automotive industry. He noted that it was not much used in Japan whereas the U.S. market for GALFAN applications in the automotive was much much larger.

NISSHIN STEEL MARKETING PRESENTATION:

Dr. Hirose started by saying that 5500 tons of GALFAN had been produced in 1986 and 6,000 more tons were planned for 1987. Half of that material would go to the pre-painted market. The bare application of GALFAN was headed for pre-engineered metal building market with mainframes in the heavy gauge range of 2 to 4 millimeters. These heavy gauge applications will also have a heavy GALFAN coating. He also noted a large part of their market was for farm fence which was not wire, it was actually fabricated sheet. They are performing soil tests. There is much activity and they have encouraging results.

SUMITOMO MARKETING PRESENTATION:

Mr. Shimada said that Sumitomo started GALFAN production as a trial 1,000 ton run in May of 1986. They did produce a total of 1,300 tons in 1986 and planned on producing 6,000 tons in 1987. 40% of that planned tonnage would go for the precoated market which would mainly be roofing in the .27 to .28 millimeter gauge range. This is the product they offer the ten-year red rust warranty on. The other 60% - the bare chromated material, this would be heavy gauge material in the 1.2 millimeter gauge range which ends up to be framing for domestic housing.

Mr. Yamamoto spoke up for the Japanese Galvanizers Association noting that two years ago they had initiated a design contest for galvanized applications. This included GALFAN for the contest but not Galvalume due to the high aluminum content. He noted the response was good and felt publicity would be good for both galvanize and GALFAN.

Dr. Lynch then asked Dr. Goodwin if he knew of any figures for tonnage on Yodagawa Steel since there was no representative present for the marketing meeting. Dr. Goodwin replied that he did not have those figures available and would have to refer back to previous minutes from the last licensees meeting in Siegen, West Germany. (From the licensee meeting in Tokyo, April 1986 Yodagawa had planned to produce 15,000 tons for 1986. There are no available figures for planned tonnage in 1987.)

Dr. Lynch then reviewed the tonnage figures just presented and noted the total worldwide GALFAN tonnage was going up and the total market for GALFAN was expanding on a worldwide basis.

Dr. Lynch noted that standards and specifications were starting to come around for GALFAN; the ASTM efforts for fence framework for galvanize, GALFAN, and PVCs; there is an effort for a culvert spec; there is work being performed for a general requirement sheet for materials; there is the Ford tubing spec available; and ASTM is also working on a new mischmetal standard concerning lanthanum and cerium.

Dr. Lynch then reviewed the current worldwide applications for GALFAN. Dr. Lynch noted that Hoesch Stahl had advised him that pre-painted GALFAN had out performed pre-painted Galvalume in the detergent test that Hoesch had performed.

Dr. Lynch noted that the only production part on the road in the American automotive market made of GALFAN was the transmission line tubing used in all Ford cars. He noted all oncoming parts will be produced as was previously presented. He then reviewed the automotive market for GALFAN, highlighting the use of the deep drawn parts which take advantage of GALFAN's improved ductility. Dr. Lynch then directed his comments to the group by asking if there were any trade restrictions or quotas or anything which might be preventing the use of GALFAN. These factors that may be holding back GALFAN should be highlighted so that they can be addressed. He noted that the group should think about anything that could be raised for future discussion that might be holding back the use of GALFAN. He also noted that the success of GALFAN may in itself be holding back the use of GALFAN. He referred back to the Weirton presentation noting that users and producers are proceeding cautiously, not wanting to rush into the market and wanting more time to evauate more testing.

Dr. Lynch then reviewed the basic properties of GALFAN, including the corrosion resistance, the excellent coating ductility, and its excellent paintability. He continued by reviewing the advantage of minimized spangle GALFAN and asked for comments on what is minimum spangle GALFAN. He raised the question of whether there should be a standard specification for minimized spangle GALFAN and if so, how would that standard be determined. Dr. Goodwin replied by noting that the zinc rich areas of the coating behaved more like a galvanized coating. The eutectic areas of the coating behaved more as GALFAN. The surface appearance of a minimized spangle GALFAN shows little or no cells. A regular spangle will show a normal spangle. He added that the cell size depends on certain variables such as gauge of the base metal bath temperature and the cooling rate of the coating. All these listed variables may be part of a classification system for minimized spangle GALFAN. Dr. Lynch then raised a question if it would be appropriate for CRM or the GALFAN producers to consider such a specification or standard. He noted that standardization allows for ease of product selection. Dr. Goodwin noted that to produce to such a standard or specification such product would have to be consistent and reproducable and also to establish such a standard, samples would have to be secured. Dr. Lynch then reviewed the testing and performance of GALFAN sheet.

He continued by saying that over the past two days much information had been presented and there is now an overwhelming amount of information available about GALFAN performance. He noted that it was a positive move by ILZRO to establish the GALFAN Technical Resource Center so that the coordination of all this information can take place and reiterated the need and the ongoing revision of the technical manual for GALFAN. He did note that more information was necessary on fabrication of GALFAN. This information should come from in-plant experience. Dr. Goodwin noted that some information is available and could be pulled together for presentation. He also said that such information could encourage expansion of the market. Dr. Lynch reiterated that the sharing of information can only help the total market and it will help everyone involved. He also noted that there is now much more welding information available which can help determine further research direction. That welding information may also now be incorporated with the adhesive bonding research being done. Samples would be appreciated.

Mr. Gimigliano spoke up for Weirton because the Weirton representatives had at that time left the meeting. Weirton Steel had four suggestions and/or questions for discussion during the licensees meeting:

1) The new GALFAN technical manual is desparately needed now.

2) They suggested that the licensees meetings be changed to once a year due to the high cost of international travel.

3) The question was raised: Other than the written word GALFAN, has there been any thought to a GALFAN symbol or logo? One customer wants to include it on their product.

4) The questions was asked if the licensees meeting minutes could be written and distributed in a more reasonable time, say within two months.

Dr. Goodwin then replied to those questions by starting with what he considered the easiest answer. The logo is available for use and if trademark protection is required ILZRO will pursue the legal aspects involved. On the subject of licensee meeting frequency, it appears that twice a year is a useful frequency with good attendance. Dr. Goodwin asked for any comments on changing the meeting to once a year. As there were no comments, he moved on to the third part. Concerning the minutes, Dr. Goodwin noted that it is hard to do any better and welcomed the challenge for anybody else to do it. And finally, he said that the new technical manual is forthcoming. He noted the information is being put together and publication should commence by early summertime.

FUTURE TOPICS:

Dr. Lynch raised the question wondering if there were any topics which should be included for future licensee meetings. If so, those topics should be relayed to the GALFAN Technical Resource Center. Dr. Goodwin then noted that he would be pleased to know of any new topics for discussion, noting that the best meetings arise from good preparation; so he also reiterated: Let us (us being ILZRO, The GALFAN Technical Resource Center, or The Zinc Institute) know.

Dr. Cole of ILZRO raised the issue of the meeting frequency as previously discussed under Weirton's suggestion. He again invited comments as to changing the meeting frequency to once yearly. There were no comments and apparently no support for Weirton's suggestion of licensee meetings only once a year.

NEXT LICENSEE MEETING:

Dr. Goodwin told the group that he was currently working on the time schedule for the 11th GALFAN Licensees Meeting. He expressed his hope that it could be held in France at the end of October. The question was raised as to whether the date was set and Dr. Goodwin replied that it was not set. He estimated the last week of October. Dr. Goodwin also told the group that there will be ample notice of the meeting when the time and place are decided.

MISCELLANEOUS:

Dr. Hirose again raised the point about the type I GALFAN alloy with no magnesium. His question directed to Dr. Lynch or Dr. Goodwin, was: Is the zinc 5% aluminum alloy with magnesium still considered to be GALFAN alloy? Dr. Lynch replied that it was. Dr. Hirose also asked about the aluminum content range. Dr. Lynch replied the current ASTM standard is 4.7 to 6.2% and that CRM research was ongoing to determine if the aluminum rate should be expanded. Dr. Goodwin noted Dr. Hirose's concern for surface and product performance at that point. Dr. Hirose noted that in Japan there are thin coat organic coatings in the 15 to 20 micron range available and they absolutely require a bright surface. In his opinion, that requires lower aluminum. Dr. Hirose then added that some of the panels exhibited by Weirton Steel would be unacceptable for such thin coating in Japan. Dr. Lynch said he would agree but he also said that for the specific market those panels were good. Dr. Goodwin asked if the 15 to 20 micron specification was the dry film thickness. Dr. Hirose replied that it was the total dry film thickness. The question was raised by the Kawasaki representative, is a 4% aluminum content covered under the ILZRO patent. Dr. Goodwin and Dr. Lynch both replied that it is covered under the ILZRO patent and also noted that patents vary from country to country according to local laws. Dr. Lynch then asked for further comments.

As there were no further comments the meeting adjourned at 3:30 p.m.

INTERNATIONAL LEAD ZINC RESEARCH ORGANIZATION, INC.

GALFAN TECHNICAL RESOURCE CENTER

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POST OFFICE BOX 12036
RESEARCH TRIANGLE PARK, N.C. 27709-2036
TELEPHONE 361-4647 (AREA CODE 919)
TELEX: 261533
FACSIMILE: (919) 361-1957

M E M O R A N D U M

TO: GALFAN Process Licensees
GALFAN Alloy Licensees
GALFAN Suppliers
GALFAN Technical Resource Center Sponsors
Dr. D. Coutsouradis, CRM

FROM: Marshall P. Roman, Director, GALFAN Technical Resource Center MPR

DATE: June 22, 1987

SUBJECT: Minutes of the Tenth GALFAN Licensees Meeting
May 20-21, 1987 - Pittsburgh, PA, U.S.A.

Enclosed are the minutes of the subject meeting. Based on licensee reports, approximately 67,000 tons of GALFAN coated products were made in 1986. Estimated tonnage for 1987 is approximately 85,000 tons.

Also, it has been announced by RASMET KY of Finland that Ziegler S.A. has just purchased the second ZINQUENCH license. They (Ziegler) have performed several tests and have come to the conclusion that the combination of ZINQUENCH and GALFAN undisputably offer advantages both concerning appearance and metallurgical properties of the end product as well as production control.

The Eleventh GALFAN Licensees Meeting will most likely be held in France at the end of October. Notification of the exact location and date will be circulated as soon as possible.

MPR/ja

Encls.

EFFECT OF PROCESSES VARIABLES ON THE QUALITY OF GALFAN

1) GRAIN BOUNDARY DENTS
2) STUDY OF OTHER COATING DEFECTS
3) INTERMETALLIC GROWTH FOR HEAVY GAUGES.

1) GRAIN BOUNDARY DENTS.

1986 : STUDIES MADE BY DR. FUCHS AND DR. HIROSE (9TH. GALFAN MEETING - SIEGEN, NOVEMBER 1986).

- SORT OF SHRINKAGE MAINLY OBSERVED WITH AN EUTECTIC STRUCTURE
  NOT COMPLETELY REMOVED BY SKIN-PASS.
  DETRIMENTAL FOR COIL COATED SHEETS.

- DECREASE OF AL CONTENT
  -> GREATER PERCENTAGE OF ZN-RICH GLOBULES
  -> EFFECTIVE TO INHIBIT THE DENTS FORMATION
  -> CORROSION RESISTANCE MUST BE CHECKED.

- INCREASE OF COOLING RATE (20-30°C/SEC)
  -> CONCENTRATION OF ZN-RICH PARTICLES AT THE COATING SURFACE.
  -> EFFECTIVE TO INHIBIT THE DENTS FORMATION
  -> CORROSION RESISTANCE MUST BE CHECKED DUE TO LOWER AL CONTENT AT THE SURFACE.

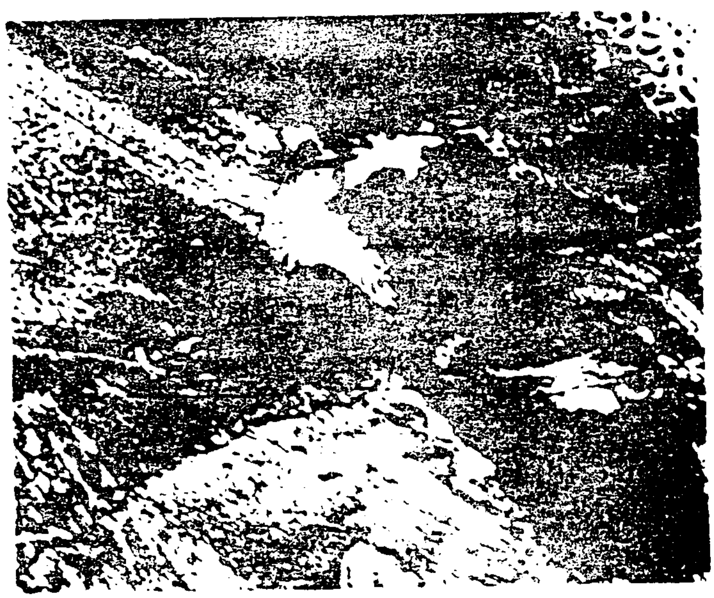
- THE EUTECTIC STRUCTURE IS HARMFUL WHEN IT IS ACHIEVED BY :
  - ADJUSTMENT OF AL CONTENT (5.2 TO 5.3 % AL)
  - VERY HIGH COOLING RATES (> 100-200°C/SEC)
  - GRAIN REFINING BY ZR ADDITION
    (HOLES AT GRAIN BOUNDARIES -> VERY ROUGH SURFACE).

INDUSTRIAL SAMPLES

HOESCH

~ 5 μ

87/138/3 750 x



WEIRTON

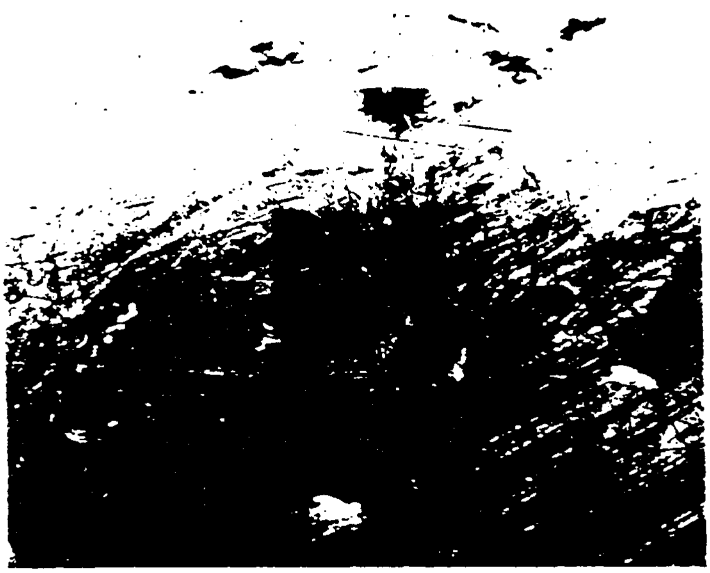
~ 3 μ

86/295/7 2000 x

INDUSTRIAL SAMPLES

WEIRTON

MACROGRAPH 5 x



86/295/5 80 x

86/295/6 2000 x

FIG. 5.23 - GALFAN SHEET WITH GRAIN BOUNDARY DENTS -
EXAMINATION WITH THE SCANNING ELECTRON MICROSCOPE

DENTS - ZIEGLER TRIAL WITH ZIRCONIUM

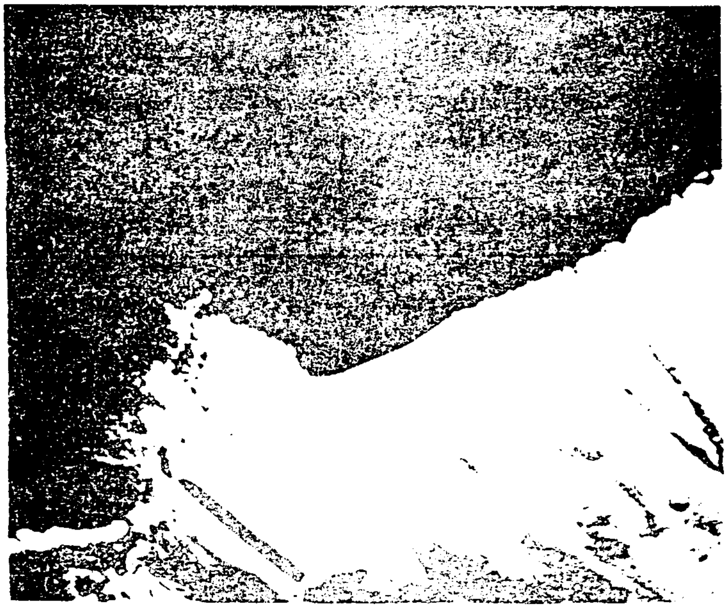
DEPTH

$\simeq$ 10-15 μ

R_A = 1.1 μ

R_T = 7.8 μ

87/81/3 200 x



87/81/2 2000 x

87/138/1 1500 x

SURFACE ASPECT OF SIMULATION SAMPLES

Zn - 5.2% Al - Cooling rate = 20-30°C/sec

DEPTH

$\simeq$ 4-6 μ

87/138/4 750 x

SURFACE ASPECT OF SIMULATION SAMPLES

ZN - 5.2% AL - SI - COOLING RATE = 20-30°C/SEC

DEPTH

∼ 5 μ

87/138/9 35 x

87/138/8 750 x

DEPTH
$\simeq 5\,\mu$

87/138/6 750 x

87/138/5 3500 x

1987 : TRIALS WITH THE SIMULATION EQUIPMENT

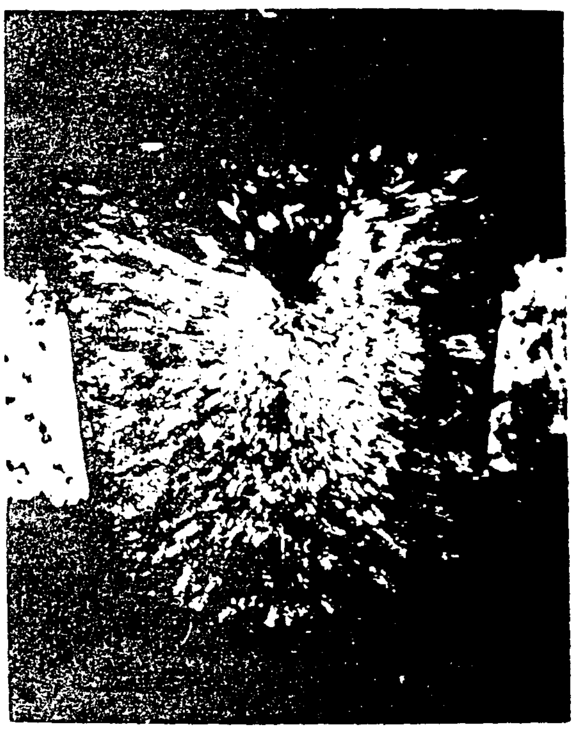
- ZN-AL-MM ALLOY WITH MAGNESIUM.
- AL CONTENTS BETWEEN 4.0 AND 5.2% (0.2% INCREMENTS).
- EFFECTS OF MG (0.01%) FOR THREE BATHS (4.0 - 4.6 - 5.2% AL).
- RIMMED STEEL (0.9MM IN THICKNESS).
- BATH TEMPERATURE 470°C
- COOLING RATES : CONVECTION COOLING (2-5°C/SEC)
  GAS JET COOLING (20-30°C/SEC).

EVALUATION :

- ROUGHNESS MEASUREMENTS
- METALLOGRAPHIC STUDY
  CROSS-SECTIONAL -> DEPTH OF BOUNDARY DENTS
  DISTRIBUTION OF PRIMARY PHASE.
  SURFACE INVESTIGATION WITH SEM.
- ADHERENCE TESTING (ERICHSEN - T BEND).
- CORROSION RESISTANCE (ACCELERATED TESTS AND ATMOSPHERIC EXPOSURE)
  4.0 - 4.6 - 4.8 - 5.2% AL
  LOW AND HIGH COOLING RATE.

3.92 % AL

4.13% AL

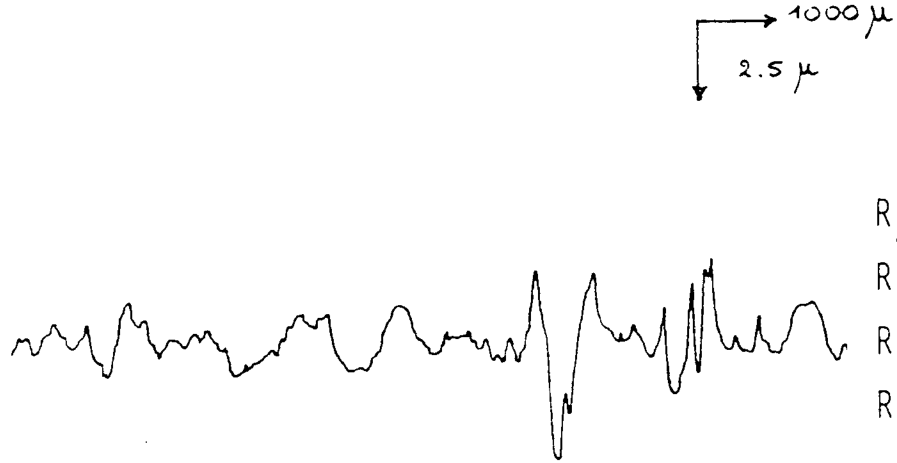


4.42 % AL

4.82 % AL

$R_T = 3.46\ \mu$

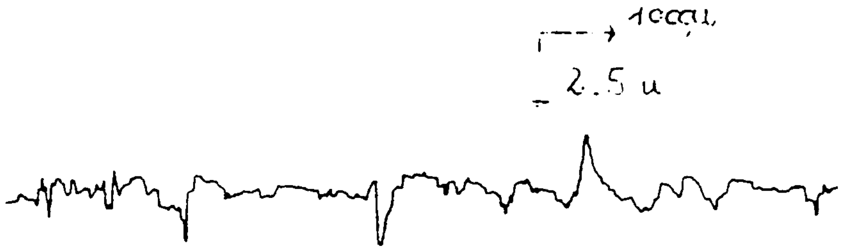
4.42% AL 2-5°C/SEC



$R_A = 0.49\ \mu$
$R_P = 2.84\ \mu$
$R_Z = 3.12\ \mu$
$R_T = 6.18\ \mu$

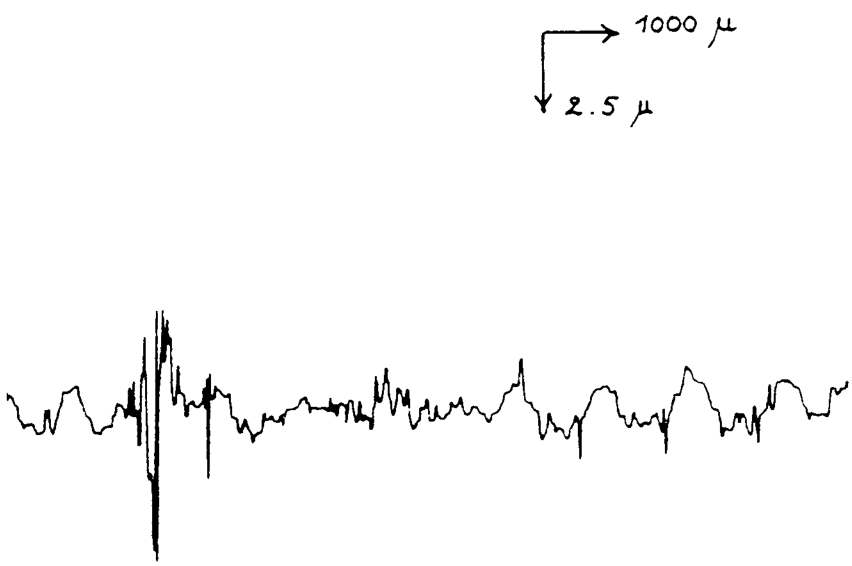
4.82% AL 2-5°C/SEC

ROUGHNESS PROFILES



$R_A = 0.31\ \mu$
$R_P = 2.00\ \mu$
$R_Z = 3.31\ \mu$
$R_T = 6.59\ \mu$

4.42% AL 20-30°C/SEC



$R_A = 0.48\ \mu$
$R_P = 3.64\ \mu$
$R_Z = 4.10\ \mu$
$R_T = 7.86\ \mu$

4.82% AL 20-30°C/SEC

- TECHNICAL REPORTS OF LICENSEES DURING THE TECHNICAL MEETINGS
- COLLATING OF DOCUMENTS FILLED UP BY LICENSEES (OPERATING PARAMETERS/COATING DEFECTS)
- METALLOGRAPHIC STUDIES MADE AT CRM.

ORIGINS OF DEFECTS :

- WETTABILITY PROBLEMS
- ENTRAPMENT OF PARTICLES IN THE COATING
- IMPROPER WIPING CONDITIONS
- COOLING AND SOLIDIFICATION PROBLEMS.

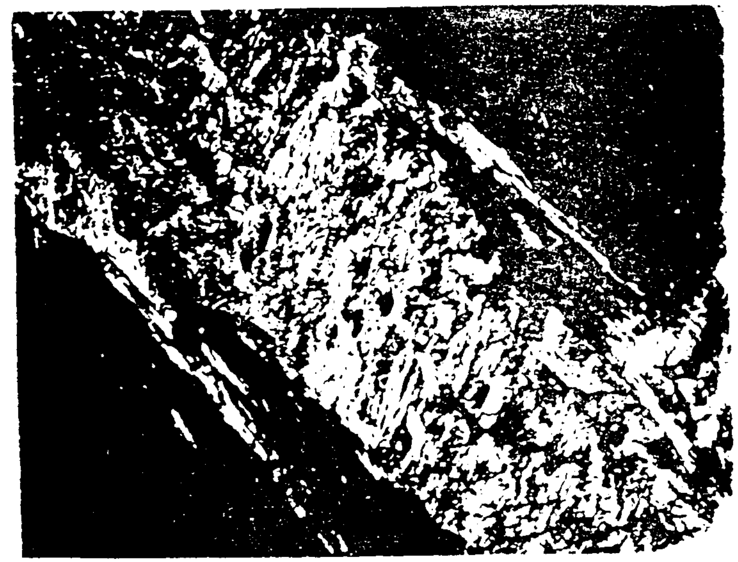
PROGRESS REPORT N° 16 IN PREPARATION.

<u>1987</u> : CONTACTS WITH LICENSEES

METALLOGRAPHIC STUDIES OF COATING DEFECTS

IDENTIFICATION OF MECHANISMS IN DEFECT FORMATION AND ELIMINATION.

RIPPLES AND TEARS 1 X



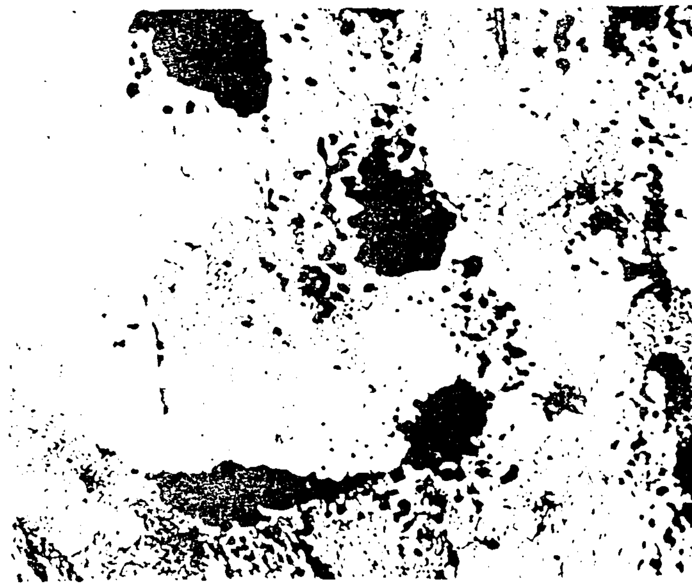
1.5 X 5 X

EDGE OVERCOATING OR "FEATHERS".

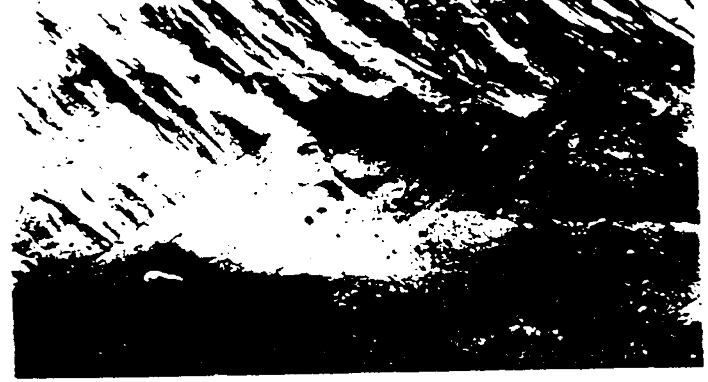
FIG. 5.19 - MACROGRAPHS SHOWING COATING DEFECTS MAINLY DUE TO IMPROPER WIPING CONDITIONS.

87/6/7 160 x

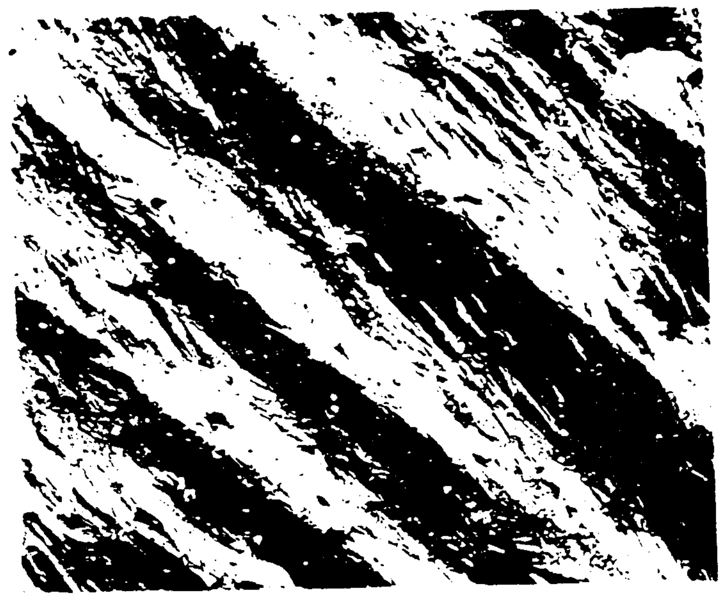
87/6/8 800 x



87/6/9 BSE 800 x



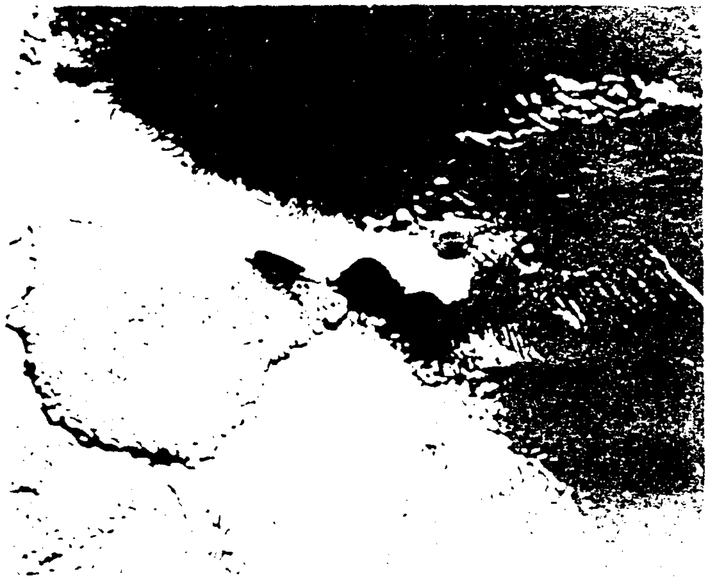
87/6/1 40 x

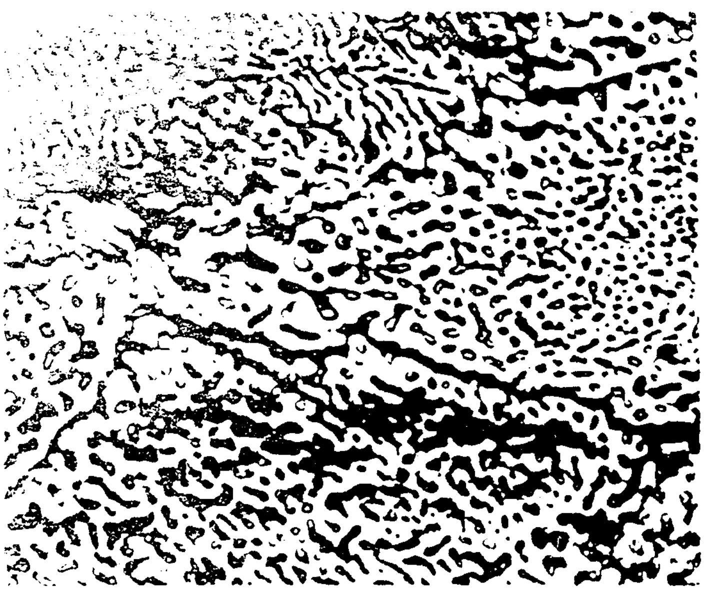


87/6/2 80 x

EDGE OVERCOATING OR "FEATHERS"

WEIRTON STEEL





87 6 3 1600 x 87/6/3

NORMAL AREAS OVERCOATED

3) INTERMETALLIC GROWTH FOR HEAVY GAUGES.

1986 : - Heavy gauges (> 1.5 - 2.0 mm)

  -> Irregular growth of intermetallic compounds (very strong Fe-Al reaction).
  Detrimental for corrosion resistance.

- Need to reduce the inlet temperature.
  -> Wettability problems.

- Study made at CRM
  (Progress report n° 15 - A. Galfan alloy specification).
  Inhibiting action of Si for the Fe-Al reaction.

1987 : - Simulation trials (silicon containing Galfan)
  Si < 0.015%.

- Al determinated by the dents study.

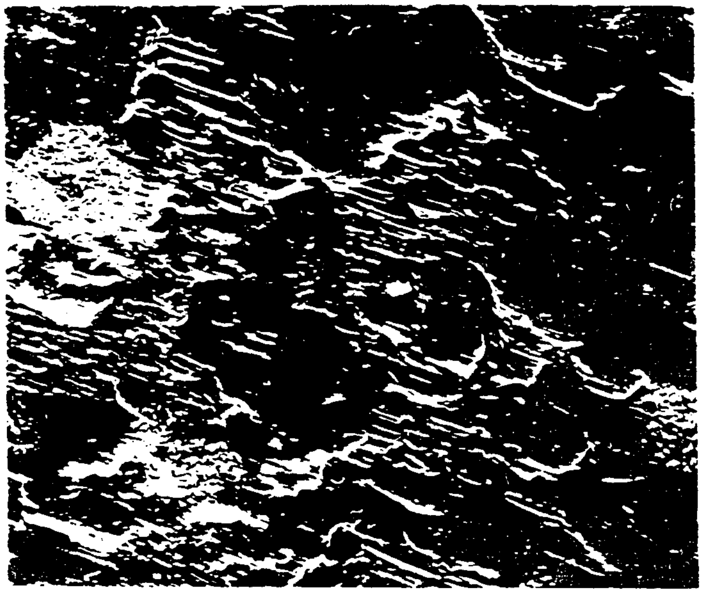
- Bath temperatures 450 - 460 - 470 - 480°C.

- Cooling rates : convection
  gas jet cooling.

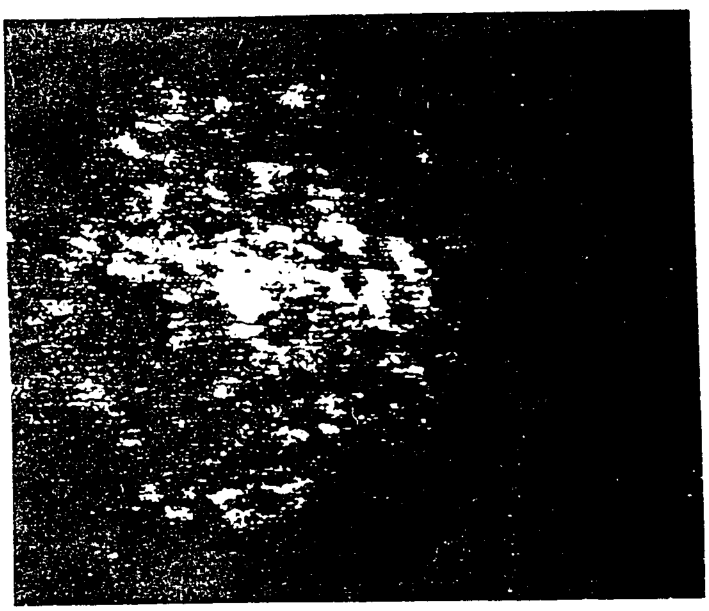
- Immersion time : 5 sec.

- Influence of sheet thickness
  (cold-rolled and hot-rolled steel).

SURFACE ASPECT AFTER SELECTIVE PICKLING

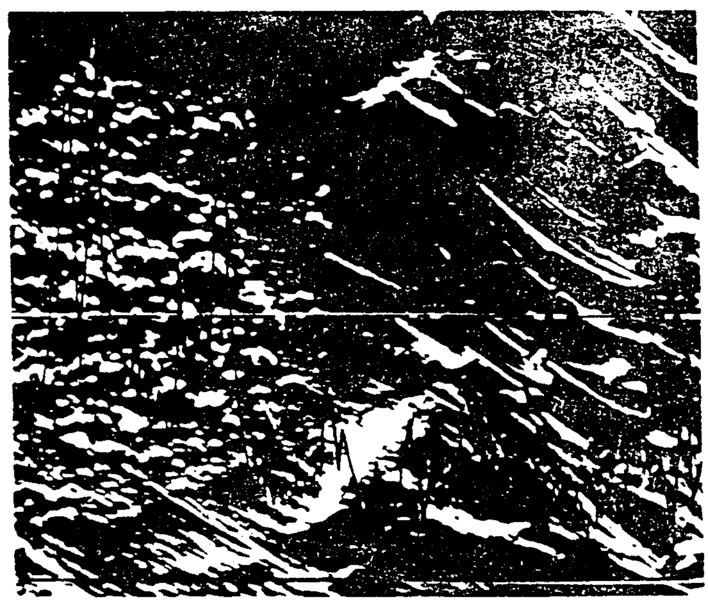


87/49/34 200 x



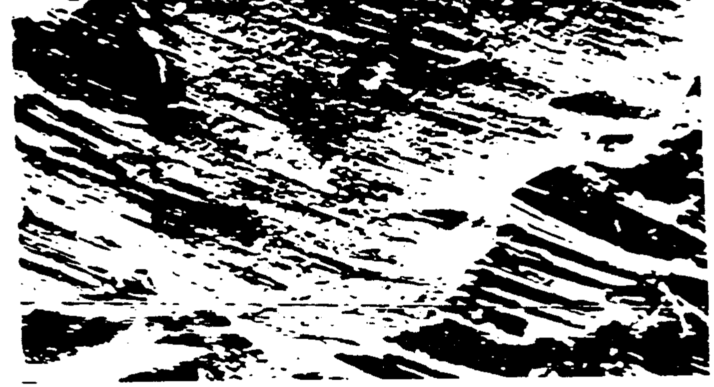
87/49/38 800 x

AL X-IMAGE

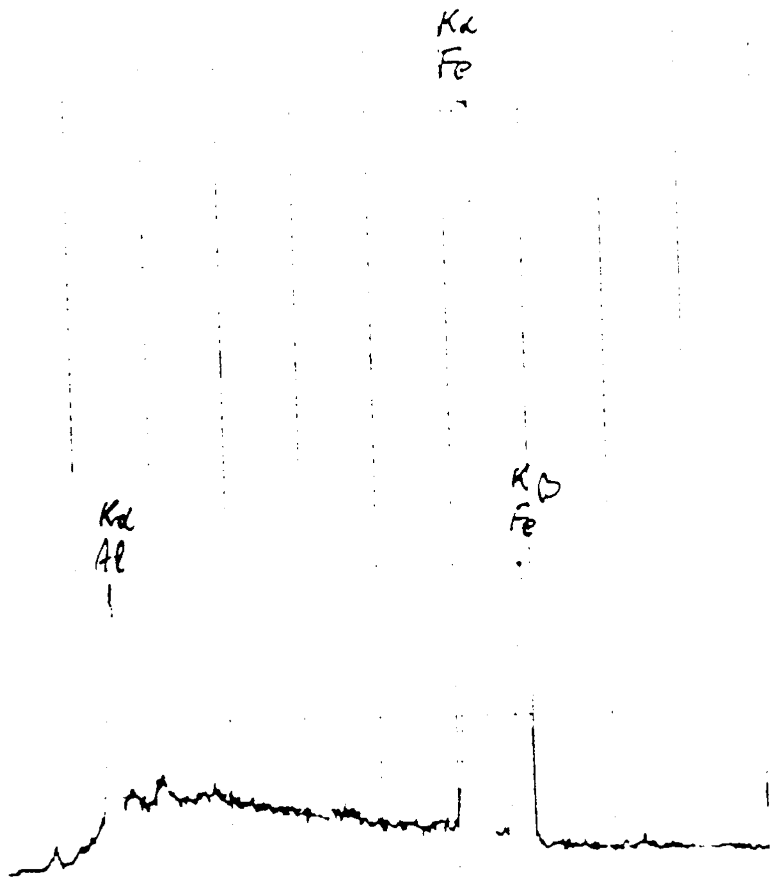


87/49/40 800 x

AL LINE SCAN

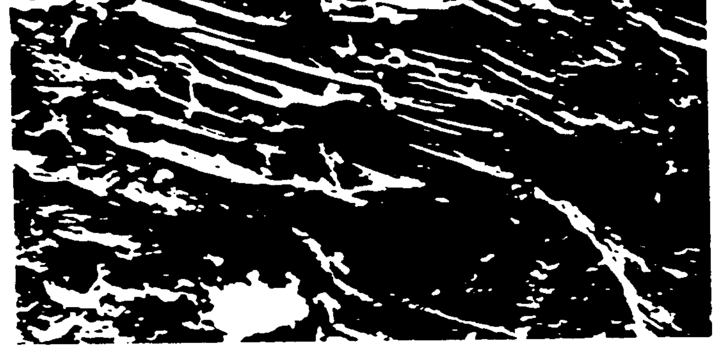


87/49/36 800 x

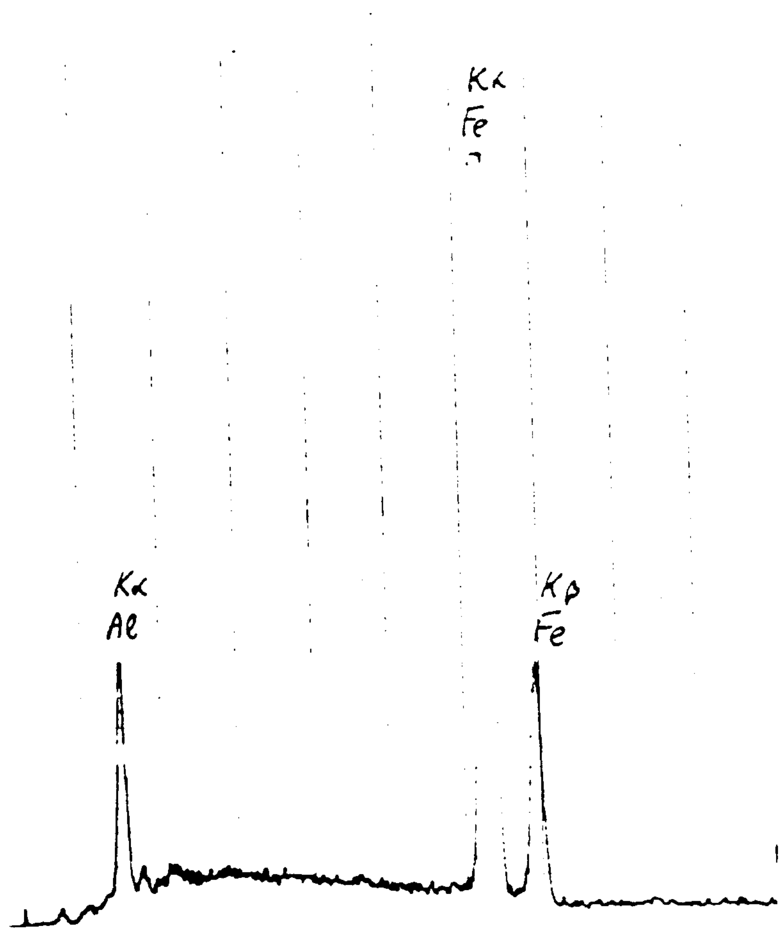


4.67% AL
94.58% FE
0.75% ZN

KEVEX ANALYSIS (SEM)

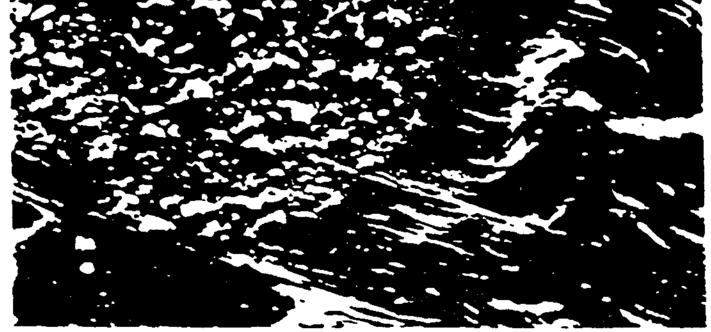


87/49/33 800 x

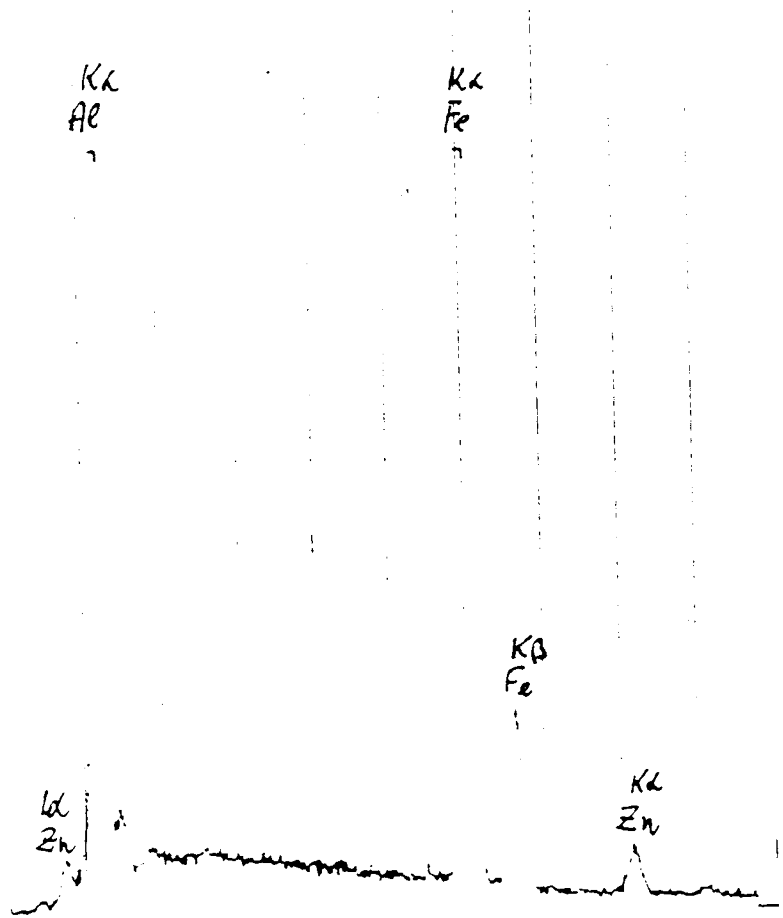


5.25% AL
93.79% FE
0.96% ZN

KEVEX ANALYSIS (SEM)



87/49/39 800 x



36.94 % AL
58.20 % FE
4.86 % ZN

KEVEX ANALYSIS

DRAFT #~~6~~7 5/12/86

ASTM ~~AWWW/AWWWM~~ A875/A875M

Standard Specification for

STEEL SHEET, ZINC-5% ALUMINUM-MISCHMETAL ALLOY-COATED BY THE HOT-DIP PROCESS[1]

This standard is issued under the fixed designation AWWW; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers zinc-5% aluminum-mischmetal (Zn-5Al-MM) alloy-coated steel sheet in coils and cut lengths coated by the hot-dip process. This product is intended for applications requiring corrosion resistance, formability and paintability. The material is produced to various Zn-5Al-MM alloy coating weights, as shown in Table 1, designed to produce coatings compatible with the service life required. Zn-5Al-MM alloy-coated steel sheet can be produced with the following types of coatings:

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[1] This specification is under the jurisdiction of ASTM Committee A-5 on Metallic Coated Iron and Steel Products and is the direct responsibility of Subcommittee A05.11 on Sheet Specifications.

Current edition approved_________. Published____________.

1.1.1 Regular coating structure

1.1.2 Minimized coating structure

1.1.3 Wiped

1.1.4 Differential

1.2 Zn-5Al-MM alloy-coated sheet is normally available in commercia quality, lock-forming quality, drawing quality, drawing quality special killed and structural (physical) quality.

1.3 This specification is applicable to orders in either inch-poun units (as AWWW) or acceptable metric units (as AWWWM). Inch-pound units and metric units are not necessarily equivalent.

2. Applicable Documents

2.1 ASTM Standards:

A 90 Test Method for Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles.[2]

A 370 Methods and Definitions for Mechanical Testing of Steel Products.[3]

A525/A525M ~~A 525~~ Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process.[2]

A 700 Practices for Packaging, Marking, and Loading Methods for Steel Products for Domestic Shipment.[3]

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[2] Annual Book of ASTM Standards, Vol 01.06

[3] Annual Book of ASTM Standards, Vols 01.01-01.05

A 754 Test Method for Coating Thickness by X-Ray Flourescence.[2]

B 750 Zinc-5% Aluminum-Mischmetal Alloy in Ingot Form for Hot-Dip Coatings.[4]

D 2092 Recommended Practices for Preparation of Zinc-Coated Steel Surfaces for Painting.[5]

E 27 Method for Spectrographic Analysis of Zinc and Zinc Alloys by the Solution-Residue Technique.[6]

E 29 Recommended Practice for Indicating Which Places of Figures Are to Be Considered Significant in Specified Limiting Values.[7]

E 47 Method for Chemical Analysis of Zinc Die-Casting Alloys.[7]

E 376 Recommended Practice for Measuring Coating Thickness by Magnetic-Field or Eddy-Current (Electromagnetic) Test Methods.[2]

2.2 Military Standards:

MIL-STD-129 Marking for Shipment and Storage.[8]

MIL-STD-163 Steel Mill Products, Preparation for Shipment and Storage.[8]

2.3 Federal Standards:

Fed. Std. No. 123 Marking for Shipments (Civil Agencies).[8]

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[4] Annual Book of ASTM Standards, Vol 02.04

[5] Annual Book of ASTM Standards, Vol 06.01

[6] Annual Book of ASTM Standards, Vol 03.06

[7] Annual Book of ASTM Standards, Vol 03.05

[8] Available from Naval Publications and Forms Center, 5801 Tabor Ave., Philadelphica, PA 19120

2.4 Other Standards

GF-1 Standard Practice for Determination of Cerium and Lanthanum Compositions in Galfan Alloy (5% Al-0.04% La-0.04% Ce-Bal SHG Zn)[9]

ANSI/ASME B32.3M Preferred Metric Sizes for Flat Metal Products.[10]

3. Terminology

3.1 Definitions:

3.1.1 commercial quality - a term applied to sheet steel intended for applications where material is subjected to bending or moderate forming.

3.1.2 lock-forming quality - a term applied to sheet steel intended for applications where material is subjected to machine lock forming.

3.1.3 drawing quality - a term applied to sheet steel intended for fabrication of parts where drawing or severe forming may be involved.

3.1.4 drawing quality, special killed - term applied to sheet steel intended for fabrication of parts where particularly severe drawing or forming may be involved or essential freedom from aging is required.

3.1.5 structural (physical) quality - a term applied to sheet steel intended for applications where mechanical properties are

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[9] Available from International Lead Zinc Research Organization, 292 Madison Avenue, New York, N.Y. 10017

[10] Available from American National Standards Institute, 1470 Broadway, New York, N.Y. 10018

specified or required. Such properties or values include those indicated by tensile, hardness, or other commonly accepted mechanical tests.

3.1.6 differentially coated - sheet having a specified "coating designation" on one surface and a significantly lighter specified "coating designation" on the other surface. The single side relationship of either specified "coating designation" is the same as shown in Note 1 of Table 1 regarding uniformity of coating.

3.1.7 mill phosphatized - sheet chemically processed by the producer to prepare the surfaces for immediate painting without further treatment except normal cleaning (refer to Practices D 2092). Since this is a surface treatment only, all other characteristics of the coating remain unchanged. This sheet is normally produced to all coating designations in Table 1.

3.1.8 extra smooth or skin passed - material produced by skin passing the coated sheet to impart a higher degree of smoothness than is normal for the as-coated product, as in the case of critical painted surfaces.

3.1.9 chemical treatment - a passivating chemical treatment normally applied to coatings to retard the formation of white corrosion products during shipment and storage. However, the inhibiting characteristics of the treatment are limited and if a shipment is received wet, the material should be used or dried immediately.

3.1.10 oiling - a coating applied to Zn-5Al-MM alloy-coated sheet steel alone or in addition to the chemical treatment for further protection against the onset of storage corrosion. If chemical treatment is undesirable because of further processing such as phosphatizing or painting, an oil coating offers protection during shipment storage. The oil coating is intended to be a corrosion inhibitor only and not as a rolling or drawing lubricant.

3.2 Description of Terms Specific to this Standard:

3.2.1 regular coating structure- sheet coated on continuous lines to the coating designations prefixed "GF" or "ZGF" as shown in Table 1. Regular grain structure is the result of unrestricted grain growth during normal solidification.

3.2.2 minimized coating structure - sheet characterized by a finer metallurgical coating structure obtained by a treatment designed to restrict formation of the normal coarse grain str formed during solidification of the alloy coating.

3.2.3 wiped - coated sheet produced by wiping down the molte zinc alloy as it leaves the pot. This product has a light Zn-5Al-M a coating and may have striations of the surface of the coati With the Zn-5Al-MM coating, wiping is employed to produce t coating thickness product. ~~and not a~~ ~~zinc-iron~~ ~~alloy coati the case with galvanized sheet.~~

3.3 Abbreviations:

3.3.1 MM - mischmetal.

3.3.2 Zn-5Al-MM - Zinc-5% Aluminum-Mischmetal

4. General Requirements for Delivery

4.1 The requirements of the purchase order, the individual material specification, and this general specification shall govern in the sequence stated.

4.2 Zn-5Al-MM alloy-coated sheet in coils and cut lengths is produced to thickness only expressed as decimal inches (millimetres) and thickness tolerances apply. The thickness of the sheet includes both the base steel and the coating.

5. Manufacture

5.1 The base metal shall be made by the open-hearth, basic-oxygen, or electric-furnace process.

6. Chemical Requirements

6.1 Chemical composition of the base metal for Commercial Quality (CQ), Lock-Forming Quality (LFQ), Drawing Quality (DQ), Drawing Quality, Special Killed (DQSK), and Structural (Physical) Quality (SQ) are shown in Table 2.

6.2 An analysis of each cast or heat (formerly ladle) of steel shall be made by the producer to determine the percentage of carbon, manganese, phosphorus, sulfur, and any other elements specified or restricted by the applicable specification.

6.2.1 When requested, cast or heat (formerly ladle) analysis for elements listed or required shall be reported to the purchaser or his representative.

6.3 Product analysis (formerly check) may be made by the purchaser on finished material.

The chemical analysis so determined shall be in accordance with the limits specified in Table 2, as modified by the tolerances in Table ~~3.~~ ~~The several determinations~~

~~of any element shall not vary above or below the specified range.~~

6.3.1 Capped or rimmed steels are not technologically suited to product analysis due to the nonuniform character of their chemical composition, and therefore, the tolerances in Table 3 do not apply. Product analysis is appropriate on these steels only when misapplication is apparent.

6.3.2 Product analysis for phosphorus or sulfur is not technologically appropriate because of segregation of these elements in all types of steel. Product analysis is appropriate only when misapplication is apparent.

6.3.3 Samples for product analysis shall be drillings through stripped areas in sufficient numbers to represent the coil or lift adequately. At least three pieces shall be selected, but if the product of more than one mill lift or coil is involved, six pieces shall be selected.

6.4 Coating Bath Analysis - The bath metal used in continuous hot-dip Zn-5Al-MM alloy-coating shall meet the chemical composition limits specified in ASTM B750.

6.4.1 Method of Analysis - The determination of chemical composition shall be made in accordance with suitable chemical (Method E47), spectrochemical (Method E27) or other methods. In case of dispute, the results secured by Method E47 shall be the basis of acceptance.

6.4.2 A standard practice for X-ray fluorescence spectrometry for determination of cerium and lanthanum in a zinc-5% aluminum mischmetal alloy has been established by the International Lead Zinc Research Organization (Standard Practice GF-1).

7. Mechanical Requirements (Base Metal)

7.1 Bend - For all qualitites other than structural (physical) quality the bend test specimen shall be capable of being bent through 180° flat on itself in any direction without cracking of the base metal on the outside of the bent portion. Bend test requirements for structural (physical) quality are shown in Table ~~4.~~ 5

Base metal bend tests are not required by sheets intended for corrugated roofing or siding.

7.2 ~~Tension~~ Tensile Properties - steel ordered as structural (physical) quality shall conform to the limits prescribed in Table ~~5.~~ 4

7.3 When base metal mechanical properties are required by the applicable specification they shall be determined by the methods described in Method A370.

7.4 In determining the base metal mechanical properties, base metal thickness shall be measured after stripping the coating from the ends of the specimen contacting the grips of the tension testing machine, before testing.

7.5 Base Metal Test Specimens:

7.5.1 Test specimens shall be prepared from finished material.

7.5.2 Specimens for base metal tension tests shall be taken longitudinal and shall be selected and machined to the standard rectangular tension test specimen with 2-in gage length as outlined in Method A370.

7.5.3 Specimens for base metal bend tests shall be as free as possible of burrs. Filing or machining to remove burrs is permitted.

If any specimen develops a flaw it shall be discarded and a new specimen substituted. Cracks of the base metal developing at the edge of the specimen or coarse grain developing at the line of the bend shall be disregarded.

8. Coating Requirements

8.1 Coating Weight (mass):

8.1.1 The weight (mass) of coating shall conform to the requirements for triple and single-spot minimum checks prescribed in Table 1 for the specific coating designation. The weight (mass) of coating is the total amount on both sides of a sheet, except in the case of a differential coating where the coating weight (mass) on each side is one half that prescribed in Table 1. For example, a GF90/GF30 (ZGF275/ZGF90) differentially coated sheet would have a nominal coating weight of 0.45 oz/ft^2 (138g/m^2) on one side and 0.15 oz/ft^2 (45g/m^2) on the opposite side of the same sheet.

8.1.2 When purchaser wishes to make tests to ascertain compliance of this specification for coating weight (mass) on a lot of any specific item of coated sheet, the procedure to be employed is as outlined in Methods A90 in conjunction with the sampling procedure provided in 8.1.3, 8.1.4, and 8.1.5, except that for this specification it refers to Zn-5Al-MM coated sheet instead of galvanized sheet.

8.1.3 Triple-Spot-Test- The triple-spot test shall be made in accordance with the procedure of Methods A90. The result shall consist of the average of determinations from the three specimens cut from the test sheet or sample piece as provided in 8.1.5.

Material 18 in. (450mm) and under in width is normally produced by slitting from wider width coils and therefore is subject to the single-spot test only. Material slit after leaving the producer's works is subject to the single-spot test only.

8.1.4 Single-Spot Test - The minimum check limit by the single-spot test shall be that one of the triple-spot test bearing the lightest coating, or the purchaser may select a single specimen taken from any part of the test sheet providing it is taken within the boundaries outlined in 8.1.5. For material narrower than 2.25 in. (50mm), the test specimen length shall be chosen to give an area of approximately 5 in.^{2} (3000 mm^2).

8.1.5 Test specimens for coils and cut lengths coated in coils shall be taken from a sample piece approximately 1 ft. (300mm) in length by the as-coated width. For the triple-spot test, one specimen shall be cut from the middle of the width and one from each side not closer than 2 in. (50mm) from the side edge.

8.1.6 Coating Thickness Measurements with Magnetic Gages - A reasonable estimate of weight (mass) of coating may be obtained by comparing coating thickness measurements made with magnetic gages to the values show in Table 1. An accuracy of $\pm$ 15% in determining the thickness may be realized by following the recommended practice for magnetic instruments described in Recommended Practice E376. This test may be used as a basis for acceptance but rejection shall be governed by the weight (mass) of coating tests described in 8.1.1 through 8.1.5.

8.1.7 Coating Thickness Measurements with X-Ray Fluorescence Types Gages - The referee method to be employed shall be as agreed upon between producer and consumer. Where no method is specified, the X-ray fluorescence method, in accordance with Test Method A754, shall be employed provided the data are available and evidence of appropriate calibration control is maintained. Where the X-ray fluorescence data are not available or no evidence of calibration control is maintained, the method described in Methods A90 shall be employed.

8.2 Coating Bend Test:

8.2.1 Coated sheet designated by prefix "GF" or "ZGF" shall be capable of being bent through 180° in any direction without flaking of the coating on the outside of the bend only. The coating bend test inside diameter shall have a relation to the thickness of the specimen as prescribed in Table 6, except for structural quality steels. Flaking of the coating within 1/4 in (6mm) of the edge of the bend specimen shall not be cause for rejection. ~~Bend Tests are not required of sheets intended for corrugated roofing or siding.~~

Delete

8.2.2 Additional coating bend test requirements for structural (physical) quality steels coated with Zn-5Al-MM alloy are found in Table ~~4~~ 5.

8.2.3 Coating bend test specimens shall be 2 to 4 in. (50 to 100mm) wide. The specimen shall be cut not less than 2 in. (50mm) from the edges of the test sheet.

9. Retests

9.1 If one test fails for either base metal or coating, two more tests shall be taken at random from the same lot of any specific item. Both retests must conform to the requirements of the specification; otherwise, the lot shall be rejected.

9.2 When the percent of elongation is less that the specified minimum and any part of the fracture is outside the middle half of the gage length as scribed before the test, the test shall be discarded and a retest shall be permitted.

10. Dimensions and Tolerances

10.1 All dimensions and tolerances applicable to coated sheet are contained in the Tables. The appropriate tolerance tables shall be identified in each individual specification.

11. Workmanship

11.1 Cut lengths shall have a workmanlike appearance and shall not have defects of a nature or degree for the grade and quality ordered that will be detrimental to the fabrication of the finished part.

11.2 Coils may contain some abnormal imperfections which render a portion of the coil unusable since the inspection of coils does not afford the producer the same opportunity to remove portions containing imperfections as in the case with cut lengths.

12. Product Information

12.1 Sheet in coils is subject to coil "breaks" when coiled to a smaller inside diameter than is compatible to the thickness of the sheet. To minimize this condition, sheet heavier than 0.0291 in. (0.75mm) should be ordered with a minimum 24 in. (600mm) inside diameter and a minimum of 20 in. (500mm) for thinner material. In further processing, such as slitting, the material should not be rewound on a smaller inside diameter than received.

13. Packaging, Marking, and Loading

13.1 It is common practice to use the methods of packaging as listed in the latest revision of Recommended Practices A700.

13.2 Purchaser may specify other than 13.1.

13.3 Abrasion during transit may have an effect on the appearance of coated steel. This condition is minimized if the product is oil

13.4 When specified in the contract or order, and for direct shipments to the government, when Level A is specified, preservatio packaging, and packing shall be in accordance with the Level A requirements of MIL-STD-163. Marking for shipment shall be in accordance with Fed. Std. No. 123 for civil agencies and MIL-STD-12 for military agencies.

14. Inspection

14.1 The producer shall afford the purchaser's inspector all reasonable facilities to assure him that material is being produced in compliance with the specification. Unless otherwise specified, all inspection and tests, except product analysis, shall be made at the producer's works prior to shipment. Such inspection or sampling shall be made concurrently with the producer's regular inspection and test operations unless it causes interference with normal operations or is otherwise specified.

14.2 Responsibility for Inspection - Unless otherwise specified in the contract or purchase order, the producer is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the producer may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the purchaser.

The purchaser reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

15. Rejection and Rehearing

15.1 Unless otherwise specified, any rejection shall be reported to the producer within a reasonable time after receipt of material by the purchaser.

15.2 Material that is reported to be defective subsequent to the acceptance at the purchaser's works shall be set aside, adequately protected, and correctly identified. The producer shall be notified as soon as possible so that an investigation may be initiated.

15.3 Samples that are representative of the rejected material shall be made available to the producer. In the event that the producer is dissatisfied with the rejection, he may request a rehearing

TABLE 1 Coating Designation and Minimum Coating Test Limits for Zn-5Al-MM Alloy Coated Steel Sheet (Total Both Sides)

Note 1 - The coating designation number is the term by which this product is specified. The weight (mass) of coating in ounces per square foot (or kilograms per square metre) of sheet refers to the total coating on both surfaces. Because of the many variables and changing conditions that are characteristic of continuous hot-dip coating, the ~~zinc~~ Zn-5Al-MM alloy coating is not always evenly divided between the two surfaces of an alloy coated sheet: neither is the ~~zinc~~ Zn-5Al-MM alloy coating evenly distributed from edge to edge. However, it can normally be expected that not less than 40% of the single-spot check limit will be found on either surface.

Note 2 - "No minimum" means that there are no established minimum check limits for triple and single-spot tests.

Note 3 - As it is an established fact that the atmospheric corrosio resistance of mill Zn-5Al-MM alloy coated sheet products is a direct function of coating thickness (weight or mass), the selection of lighter coating designations will result in almost linearly reduced corrosio performance of the ~~zinc~~ Zn-5Al-MM alloy coating. For example, the heavier Zn-5Al-MM alloy coatings perform adequately in bold atmospheric exposure whereas the lighter coatings are often further coated with paint or a similar barrier coating for increased corrosion resistance. Because of this relationship, products carrying the statement "meets ASTM AWWW (AWWWM) requirements" should also specify the particular coating designation.

Minimum Coating Test Limits (oz/ft2)

Coating Designation	Nominal Coating Weight oz/ft2	Minimum Check Limit: Triple-Spot Test oz/ft2 (of sheet)	Minimum Check Limit: Single-Spot Test oz/ft2 (of sheet)	Nominal Coating Thickness[A,B,C] mils	Minimum Coating Thickness - one side[B,D] mils
GF235	2.35	2.35	2.00	4.12	1.40
GF210	2.10	2.10	1.80	3.68	1.26
GF185	1.85	1.85	1.60	3.25	1.12
GF165	1.65	1.65	1.40	2.89	0.98
GF140	1.40	1.40	1.20	2.46	0.84
GF115	1.15	1.15	1.00	2.02	0.70
GF90	0.90	0.90	0.80	1.58	0.56
GF75	0.75	0.75	0.65	1.32	0.46
GF60	0.60	0.60	0.50	1.05	0.35
GF45	0.45	0.45	0.35	0.79	0.25
GF30	0.30	0.30	0.25	0.53	0.18
GF01	-	No minimum	No minimum	-	-

Minimum Coating Test Limits (g/m2)

Coating Designation	Nominal Coating Mass g/m2	Minimum Check Limit: Triple-Spot Test g/m2 (of sheet)	Minimum Check Limit: Single-Spot Test g/m2 (of sheet)	Nominal Coating Thickness[A,B,E] (μm)	Minimum Coating Thickness-One Side[B,D] (μm)
ZGF700	700	700	595	102	35
ZGF600	600	600	510	87	30
ZGF450	450	450	385	66	22
ZGF350	350	350	300	51	17
ZGF275	275	275	235	40	14
ZGF225	225	225	195	33	11
ZGF180	180	180	150	26	9
ZGF135	135	135	113	20	7
ZGF90	90	90	75	13	4
ZGF001	-	No minimum	No minimum	-	-

[A] Total thickness on both sides.

[B] Product is specified to the weight (mass) of coating in ounces per square foot (grams per square metre) with equivalent coating thickness values in inches (millimetres) given for informational purposes only.

C
The nominal coating thickness was calculated from the coating weight by using the following relationship: 1 oz/ft^2 total both sides, is equal to 0.001754 in. or 1.754 mils total both sides and is based on minimum triple spot requirements. This formula is not to be used for calculation of tensile strength of the base metal, which must be based on actual base metal thickness measurement (see ~~7.1.2~~ 7.4).

D
The minimum coating thickness on one side was calculated from 40% of the single spot test coating weight (mass).

E
The nominal coating thickness was calculated from the coating mass by using the following relationship: 100 g/m^2 total both sides, is equal to 0.01455 mm total both sides and is based on minimum triple spot test limits. This formula is not to be used for calculation of tensile strength of the base metal, which must be based on actual base metal thickness measurement (see ~~7.1.2~~ 7.4).

Delete

TABLE 2 Chemical Composition, %

Element	Commercial Quality; Lock-Forming Quality	Drawing Quality; Drawing Quality, Special Killed	Structural (Physical) Quality GRADE A	B	C	D	E	F
C, max	0.15	0.10	0.20	0.20	0.25	0.40	0.20	0.50
P, max	0.035	0.50	0.04	0.10	0.10	0.20	0.04	0.04
S, max	0.040	0.025	0.040	0.040	0.040	0.040	0.040	0.040
Mn, max	0.060	0.035	0.20	0.20	0.20	0.20	0.20	0.20

Substitute

TABLE 2 Chemical Composition, %

Element	Commercial Quality; Lock-Forming Quality	Drawing Quality; Drawing Quality, Special Killed	Structural (Physical) Quality GRADE A	B	C	D	E	F
C, max	0.15	0.10	0.20	0.20	0.25	0.40	0.20	0.50
Mn, max	0.60	0.50	—	—	—	—	—	—
P, max	0.035	0.025	0.04	0.10	0.10	0.20	0.04	0.04
S, max	0.040	0.035	0.04	0.04	0.04	0.04	0.04	0.04

TABLE 3 Tolerances for Product (Formerly Check) Analysis

Element	Upper Limit, or Maximum Specified Value, %	Tolerances, % Under Minimum Limit	Tolerances, % Over Maximum Limit
Carbon	To 0.15, incl	0.02	0.03
	Over 0.15 to 0.40, incl	0.03	0.04
	Over 0.40 to 0.80, incl	0.03	0.05
Manganese	To 0.60, incl	0.03	0.03
	Over 0.60 to 1.15, incl.	0.04	0.04
	Over 1.15 to 1.65, incl	0.05	0.05
Phosphorus	....	....	0.01
Sulfur	....	....	0.01
Silicon	To 0.30, incl	0.02	0.03
	Over 0.30 to 0.60	0.05	0.05

TABLE 4 Mechanical Requirements, Base Metal, Structural (Physical) Quality

Grade	Yield Point, min. ksi (MPa)	Tensile Strength, min. ksi (MPa)	Elongation in 2 in. (50 mm), min. %
A	33 (230)	45 (310)	20
B	37 (255)	52 (360)	18
C	40 (275)	55 (380)	16
D	50 (345)	65 (450)	12
E[A]	80 (550)[B]	82 (570)	...
F	50 (345)	70 (480)	12

[A] If the Rockwell B result is 85 or higher, no tension test is required.

[B] The yield point approaches the tensile strength and since there is no halt in the gage or drop in the beam, the yield point should be taken as the stress at 0.5 % elongation, under load

TABLE 5 Base Metal and Coating Bend Tests, Structural (Physical) Quality

Grade	Ratio of Bend Diameter to Thickness of the Specimen
A	1½
B	2
C	2½
D	[A]
E	[A]
F	[A]

[A] Base metal bend tests are not required for Grades D, E, and F.

TABLE 6 Coating Bend Test[A]

Ratio of Bend Diameter to Thickness of Specimen

(Any Direction)

	Coated Sheet Thickness (in.)		
Coating Designation	0.0381 in. to 0.0131 in.	0.0747 in. to 0.0382 in.	0.1756 in. to 0.0748 in.
GF235	2	3	3
GF210	2	2	2
GF185	2	2	2
GF165	2	2	2
GF140	1	1	2
GF115	0	0	1
GF90	0	0	1
GF75	0	0	1
GF60	0	0	0
GF45	0	0	0
GF30	0	0	0
GF01	0	0	0

	Coat~~ing~~ed Sheet Thickness (mm)		
Coating Designation	Through 1.0 mm	Over 1.0 mm Through 2.0 mm	Over 2.0 mm
ZGF700	2	3	3
ZGF600	2	2	2
ZGF450	1	1	2
ZGF350	0	0	1
ZGF275	0	0	1
ZGF225	0	0	1
ZGF180	0	0	0
ZGF135	0	0	0
ZGF90	0	0	0
ZGF001	0	0	0

[A] This table does not apply to structural (physical) quality steel sheet.

TABLE 7 Thickness Tolerances of Hot-Dip Zn-5Al-MM Alloy-Coated Sheet

Thickness Tolerance: for Widths and Thicknesses Over and Under (in.)[A,B]

Specified Widths, in.	Specified Thickness, in.					
	Over 0.101 to 0.187, incl	Over 0.075 to 0.101, incl	Over 0.061 to 0.075, incl	Over 0.043 to 0.061, incl	Over 0.023 to 0.043, incl	0.023 and thinner
To 32, incl	0.008	0.007	0.006	0.005	0.004	0.003
Over 32 to 40, incl	0.008	0.008	0.006	0.005	0.004	0.003
Over 40 to 60, incl	0.009	0.008	0.006	0.005	0.004	0.003
Over 60 to 72, incl	0.009	0.009	0.006	0.005	0.004	...

Thickenss Tolerance: for Widths and Thicknesses, Specified to Minimum Thickness (mm)[C]

Specified Width, mm		Thickness Tolerance, Plus Only, mm For Specified Minimum Thickness, mm					
Over	Through	Through 0.4	Over 0.4 Through 1.0	Over 1.0 Through 1.5	Over 1.5 Through 2.0	Over 2.0 Through 2.5	Over 2.5 Through 5.0
...	1500	0.15	0.20	0.25	0.30	0.40	0.45
1500	...	...	0.20	0.25	0.30	0.45	0.45

Thickness Tolerance: for Widths and Thicknesses, Specified to Nominal Thickness (mm)[B,C]

Specified Width, mm		Thickness Tolerance, Plus and Minus, mm For Specified Thickness, mm					
Over	Through	Through 0.4	Over 0.4 Through 1.0	Over 1.0 Through 1.5	Over 1.5 Through 2.0	Over 2.0 Through 2.5	Over 2.5 Through 5.0
...	1500	0.08	0.10	0.13	0.15	0.20	0.23
1500	...	...	0.10	0.13	0.15	0.23	0.23

[A] Thickness is measured at any point across the width not less than 3/8 in. from a side edge.

[B] Regardless of whether total thickness tolerance is specified equally or unequally, over and under, the total tolerance should be equal to twice the tabular tolerances.

[C] Thickness is measured at any point across the width not less than 10 mm from a side edge.

TABLE 8 Width Tolerances of Hot-Dip Zn-5Al-MM Alloy-Coated Sheet

Width Tolerances (in.)

(Coils and Cut Lengths Not Resquared)

Specified Width, in.	Tolerance Over Specified Width, No Tolerance Under, in.
Over 12 to 30, incl	⅛
Over 30 to 48, incl	3/16
Over 48 to 60, incl	¼
Over 60 to 72, incl	5/16

Width Tolerances (mm)

(Coils and Cut Lengths Over 300 mm in Width, Not Resquared)

Specified Width, mm		Width Tolerance, Plus Only, mm
Over	Through	
300	600	3
600	1200	5
1200	1500	6
1500	1800	8

TABLE 9 Length Tolerances of Hot-Dip Zn-5Al-MM Alloy-Coated Sheet

Cut Lengths Not Resquared (in.)

Specified Length, in.	Tolerance Over Specified Length, No Tolerance Under, in.
Over 12 to 30, incl	⅛
Over 30 to 60, incl	¼
Over 60 to 96, incl	½
Over 96 to 120, incl	¾
Over 120 to 156, incl	1
Over 156 to 192, incl	1¼
Over 192 to 240, incl	1½
Over 240	1¾

Cut Lengths Over 300 mm in Width, Not Resquared

Specified Length, mm		Tolerance Over Specified Length (No Tolerance Under), mm
Over	Through	
300	1500	6
1500	3000	20
3000	6000	35
6000	...	45

TABLE 10 Camber Tolerances of Hot-Dip Zn-5Al-MM Alloy-Coated Sheet

Note 1 - Camber is the greatest deviation of a side edge from a straight line, the measurement being taken on the concave side with a straightedge.

Note 2 - Camber tolerances for cut lengths, not resquared, as shown in the table.

Camber Tolerance of Sheet Over 12 in. wide (in)[A]

Cut Lengths, ft	Camber Tolerance, in.
To 4 incl	1/8
Over 4 to 6, incl	3/16
Over 6 to 8, incl	1/4
Over 8 to 10, incl	5/16
Over 10 to 12, incl	3/8
Over 12 to 14, incl	1/2
Over 14 to 16, incl	5/8
Over 16 to 18, incl	3/4
Over 18 to 20, incl	7/8
Over 20 to 30, incl	1 1/4
Over 30 to 40, incl	1 1/2

Camber Tolerance (mm)[B]

Cut Length, mm		Camber Tolerances[A], mm
Over	Through	
...	1200	4
1200	1800	5
1800	2400	6
2400	3000	8
3000	3700	10
3700	4300	13
4300	4900	16
4900	5500	19
5500	6000	22
6000	9000	32
9000	12200	38

A
The camber tolerance for sheet in coils is 1 in. in any 20 ft. except as shown in Table 10.

B
The camber tolerance for coils is 25.0 mm in any 6000 mm.

TABLE 11 Diameter Tolerances for Sheared Circles from Hot-Dip Zn-5Al-MM Alloy-Coated Sheet

Tolerance Over Specified Diameter, in., Zero Tolerance Under

Specified Thickness, in.	Diameters, in.		
	Under 30	30 to 48, incl	Over 48
0.061 and thinner	1/16	1/8	3/16
Over 0.061 to 0.101, incl	3/32	5/32	7/32
Over 0.101	1/8	3/16	1/4

Tolerance Over Specified Diameter mm., Zero Tolerance Under

Specified Thickness, mm		Diameters, mm		
Over	Through	Through 600	Over 600 to 1200, incl	Over 1200
...	1.5	1.5	3.0	5.0
1.5	2.5	2.5	4.0	5.5
2.5	...	3.0	5.0	6.5

TABLE 12 Out-Of-Square Tolerances for Hot-Dip Zn-5Al-MM Alloy-Coated Sheet

Out-of-square in the greatest deviation of an end edge from a straight line at right angles to a side and touching one corner. It is also obtained by measuring the difference between the diagonals of the cut length. The out-of-square deviation is one half of that difference.

Cut Lengths Over 12 in. in Width Not Resquared (in.)

The tolerance for cut lengths of all thicknesses and all sizes is 1/16 in. in each 6 in. of width or fraction thereof.

Cut Lengths Not Resquared (mm)

The tolerance for cut lengths of all thicknesses and all sizes is 1.0 mm/100 mm of width or fraction thereof.

TABLE 13 Resquared Tolerances for Hot-Dip Zn-5Al-MM Alloy-Coated Sheet

Cut Lengths Over 12 in. in Width (in.)

When cut lengths are specified resquared, the width and length are not less than the dimensions specified. The individual tolerance for over-width, over-length, camber, or out-of-square should not exceed 1/16 in. for cut lengths up to and including 48 in. in width and up to and including 120 in. in length nor 1/8 in. for wider or longer cut lengths.

Cut Lengths (mm)

When cut lengths are specified resquared, the width and the length are not less than tha dimensions specified. The individual tolerance for over-width, over-length, camber or out-of square should not exceed 1.6 mm up to and including 1200 mm in width and up to and including 3000 mm in length. For cut lengths wider or longer, the applicable tolerance is 3.2 mm.

TABLE 14 Flatness Tolerances for Hot-Dip Zn-5Al-MM Alloy-Coated Sheet, Not Specified to Stretcher-Leveled Standard of Flatness

Note 1- This table does not apply to structural (physical) quality.

Note 2- This table also applies to sheet cut to length from coils by the purchaser when adequate flattening measures are performed.

Cut Lengths Over 12 in. in Width (in.)

Specified Thickness, in.	Specified Width, in.	Flatness Tolerances, in. (Maximum Deviation From a Horizontal Flat Surface)
0.048 and thinner	To 36, incl	⅜
	Over 36 to 60, incl	⅝
	Over 60 to 72, incl	⅞
Over 0.048	To 36, incl	¼
	Over 36 to 60, incl	⅜
	Over 60 to 72, incl	⅝

Cut Lengths Over 300 mm in Width (mm)

Specified Thickness, mm	Specified Width, mm		Flatness Tolerance[A], mm
	Over	Through	
Through 1.0	...	900	10
	900	1500	15
	1500		20
Over 1.0	...	900	8
	900	1500	10
	1500	1800	15
	1800	...	20

[A] Maximum deviation from a horizontal flat surface.

TABLE 15 Flatness Tolerances for Hot-Dip Zn-5Al-MM Alloy-Coated Sheet, Specified to Stretcher-Leveled Standard of Flatness

Cut Lengths Over 12 in. in Width (in.)

Specified Thickness, in.	Specified Width, in.	Specified Length, in.	Flatness Tolerance, in. (Maximum Deviation from a Horizontal Flat Surface)
Over 0.019 to 0.032, incl	To 36, incl	To 120, incl	1/4
	Wider or longer sheet		3/8
Over 0.032	To 48, incl	To 120, incl	3/16
	Wider or longer sheet		1/4

Cut Lengths (mm)

Specified Thickness, mm	Specified Width, mm	Specified Length, mm	Flatness Tolerances[4], mm
0.35 to 0.8, incl	Through 900	Through 3000	8
	wider or	longer	10
Over 0.8	Through 1200	Through 3000	5
	wider or	longer	8

[4] Maximum deviation from a flat surface.

TABLE 16 Allowance in Width and Length for Hot-Dip Zn-5Al-MM Alloy-Coated Cut Lengths Specified to Stretcher - Leveled Standard of Flatness, Not Resquared

Note 1 - When cut lengths are specified to stretcher-leveled standard of flatness and not resquared, the allowances over specified dimensions in width and length given in the following table apply. Under these conditions the allowances for width and length are added by the manufacturer to the specified width and length and the tolerances given in Tables 8 and 9 apply to the new size established. The camber tolerances in Table 10 do not apply.

Note 2 - When cut lengths are not to have grip or entry marks within the specified length, the producer should specify "grip or entry marks outside specified length." When cut lengths may have grip or entry marks inside specified length, the purchaser should specify "grip or entry marks inside specified length."

Allowances Over Specified Dimensions (in.)

Specified Length, in.	Width, in.	Length, in.	
		Specified: "Grip or entry marks outside specified length."	Specified: "Grip or entry marks inside specified length."
To 120, incl	¾	4	3
Over 120 to 156, incl	1	4	3
Over 156	1¼	5	4

Allowances Over Specified Dimensions (mm)

Specified Length, mm		Width, mm	Length, mm	
Over	Through		Specified "grip or entry marks outside specified length"	Specified "grip or entry marks inside specified length"
...	3000	20	100	75
3000	4000	25	100	75
4000	...	30	125	100

TABLE 17 Hot-Dip Zn-5Al-MM Alloy-Coated Sheet Width Tolerances

Note- This table applies to widths produced by slitting from wider sheet.

Coils and Cut Lengths, Not Resquared Sheet, 2 to 12 in. in Width (in.)[A,B]

Specified Thickness, in.	Tolerances Over and Under Specified Width, in. 2 to 6, incl	Over 6 to 9, incl	Over 9 to 12, incl
Over 0.014 to 0.068, incl	0.008	0.016	0.032
Over 0.068 to 0.083, incl	0.012	0.016	0.032
Over 0.083 to 0.110, incl	0.016	0.032	0.032
Over 0.110 to 0.187, incl	0.032	0.032	0.032

[A] The specified width range captions noted below also apply when sheet is specified to width tolerances all over, nothing under. In such cases, the above tolerances are doubled.

[B] Tolerances based upon practice found to be generally followed by producers.

Coils and Cut Lengths, Not Resquared Sheet, 50 to 300 mm in Width (mm)

Specified Width, mm Over	Through	Width Tolerance, Over and Under, mm
50	100	0.3
100	200	0.4
200	300	0.8

TABLE 18 Hot-Dip Zn-5Al-MM Alloy-Coated Sheet Length Tolerences

Note- This table applies to widths produced by slitting from wider sheet.

Cut Length Sheets, 2 to 12 in. in Width, Not Resquared (in.)

Specified Width, in.	Tolerance Over Specified Length, Zero Under Tolerance, in.		
	24 to 60 incl	Over 60 to 120 incl	Over 120 to 240 incl
2 to 12, incl	1/2	3/4	1

Cut Length Sheets, 50 to 300 mm in Width, Not Resquared (mm)

Specified Length, mm		Tolerances Over Specified Length, Zero Tolerance Under, mm
Over	Through	
600	1500	15
1500	3000	20
3000	6000	25

TABLE 19 Hot-Dip Zn-5Al-MM Alloy-Coated Sheet in Coils, Camber Tolerances

Note- This table applies to widths produced by slitting from wider sheet.

Tolerance (in.)

Width, in.	Camber Tolerances
2 through 12, incl.	1/4 in. in any 8 ft.

Tolerance (mm)

Width, mm	Camber Tolerances
50 Through 300, incl.	5.0 mm in any 2000 mm

TABLE 20 Zn-5Al-MM Alloy-Coated Sheet Gage Numbers and Thickness[A,B]

Coated Sheet Gage No.	Thickness Equivalent for Zn-5Al-MM Alloy-Coated Sheet, in.
8	0.1681
9	0.1532
10	0.1382
11	0.1233
12	0.1084
13	0.0934
14	0.0785
15	0.0710
16	0.0635
17	0.0575
18	0.0516
19	0.0456
20	0.0396
21	0.0366
22	0.0336
23	0.0306
24	0.0276
25	0.0247
26	0.0217
27	0.0202
28	0.0187
29	0.0172
30	0.0157
31	0.0142
32	0.0134

[A] This table for information only. As stated in 4.2, the product is ordered to decimal thickness, not to gage number.

[B] The gage numbers and equivalent thickness are as listed in Specification A525 for Galvanized Sheet Gage Number.

APPENDIX

X1. Zn-5Al-MM ALLOY-COATED SHEET RECOMMENDED DIMENSIONS

Recommended Thicknesses, mm		Recommended Widths, mm	Recommended Lengths, mm
0.35	2.0	300	2000
0.40	2.2	400	2500
0.45	2.4	500	3000
0.50	2.5	600	3500
0.55	2.6	800	4000
0.60	2.8	1000	4500
0.65	3.0	1200	5000
0.7	3.2	1500	6000
0.75	3.4	2000	8000
0.8	3.5	2500	10 000
0.85	3.6	3000	12 000
0.9	3.8	3500	14 000
0.95	4.0	4000	16 000
1.0	4.2	5000	18 000
1.05	4.5	...	...
1.1	4.8	...	...
1.2	5.0	...	...
1.4	5.5	...	...
1.6	6.0	...	...
1.8	...	...	...

COMMITTEE CORRESPONDENCE

COMMITTEE: ASTM A05.11

DATE: 21 April 1987

SUBJECT: Further remarks on revision of A 875/A 875M to add NSC "Superzinc"

Address Reply to:
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Amax Metals Group
Base Precious Metals Div.
One Greenwich Plaza
Greenwich, CT 06836
(203) 629-6824

Gentlemen:

I have received additional information from NSC with regard to some points raised by Task Group members, as follows:

1) Coating weights equivalent to GF235 and GF210 have been produced by NSC and are available. This is not to say, however, that anyone is actually purchasing such coating weights.

2) NSC has determined that iron in the coating in amounts up to 0.02% is not harmful to coating quality. This is not to say that iron contents higher than 0.02% are harmful. I have no information with regard to what iron content <u>is</u> harmful.

   NSC could accept a limit of 0.02% max Fe in the spec, and this is a point which should be considered when the specification is further revised when Bernard Jennings' Task Group comes in with its report.

   For the moment, it is the NSC opinion that a limit on Fe is not important because the situation is somewhat self-regulating. Iron normallys forms dross in the bath and floats out, so that typical iron contents in the bath and coating are 0.005-0.006%.

   I would like to hear more about the reported experience at Gregory which indicates that the 0.075% max value for Galfan may be too high. Is that experience with coating thick steel, or with producing thick weight coatings?

received
4/27/87

bcc: W. Meyer 4-23-87
F. Goodwin ✓
J. Cimigliano
A. Celestino

3) NSC has not had any indication that Mg is lost in the bath, and has not had any problem with loss of Mg from ingot to coating bath. NSC does not consider the Mg range in the proposed DRAFT #5 to be too restrictive. Typical Mg contents in the bath are 0.08-0.12%.

4) NSC says that Al drops about 0.5% from ingot to bath. The Al in the coating ingots is typically 5.1-5.5%, and the Al in the bath is typically 4.5-5.0%.

5) It is the NSC opinion that the analysis of the coating on sheet is the same as the analysis of the bath. Therefore, control of the analysis of the bath is equivalent to control of the analysis of the coating.

6) No action has been taken to have specification coverage of the coating alloy ingots because it is the NSC opinion that such action would be premature. At present, there are only three companies in actual production, all in Japan. Negotiations are underway with other producers, including some in North America, but until there is production in other areas, an ingot specification is not needed.

I trust that the above information will resolve some of the comments that were made during consideration of the item by the Task Group.

Sincerely yours,

Vernon W. Butler

cc: Don Mongeon

DRAFT #5

Revision of Specification A 875/A 875M-87 to add "Superzinc"

ASTM A 875/A 875M-8x

STEEL SHEET, ZINC-5% ALUMINUM ALLOY METALLIC-COATED BY THE HOT-DIP PROCESS

1. Scope

1.1 This specification covers steel sheet, with two types of zinc-5% aluminum alloy coatings, metallic-coated by the hot-dip process, in coils and cut lengths. The alloy coating also contains small amounts of elements, other than zinc and aluminum, which are intended to improve processing and the characteristics of the coated product.

1.2 The material is intended for applications requiring enhanced corrosion resistance, formability, and paintability. There may be differences in product characteristics between Type I and Type II coated steel sheet, depending on the intended application.

1.3 The material is produced in various alloy-coating weights, designed to produce coatings compatible with the service life required.

1.4 The material is produced in two *Types*, as follows:

1.4.1 *Type I* - zinc-5% aluminum-mischmetal alloy coating, and

1.4.2 *Type II* - zinc-5% aluminum-0.1% magnesium alloy coating.

1.5 The material is produced in several *Qualities*, designed to be compatible with differing applications requirements. See 4.2.

1.6 The material is produced in various *Coating Designations*, or coating weights (thicknesses). See 4.3.

1.7 The material is produced with two coating *structures*, or *Classes*. See 4.4.

1.8 This specification is applicable to orders in either inch-pound units (as A 875) or metric [SI] units (as A 875M). The values stated in either inch-pound or SI units are to be regarded separately as standard. Within the text, the SI units are shown in brackets. The values stated in each system are not exact equivalents; therefore, each system must be used independently of the other. Combining values from the two systems may result in nonconformance with the specification.

1.9 Unless the order specifies the "M" specification designation [SI units], the material shall be furnished to inch-pound units.

2. Referenced Documents

2.1 *ASTM Standards*

A 90 Test Method for Weight of Coating on Zinc-Coated (Galvanized) Iron and Steel Articles

A 370 Methods and Definitions for Mechanical Testing of Steel Products

A 700 Practices for Packaging, Marking, and Loading Methods for Steel Products for Domestic Shipment

A 751 Methods, Practices, and Definitions for Chemical Analysis of Steel Products

A 754 Test Method for Coating Thickness by X-Ray Fluorescence

B 750 Zinc-5% Aluminum-Mischmetal Alloy in Ingot Form for Hot-Dip Coatings

D 2092 Recommended Practice for Preparation of Zinc-Coated Steel Surfaces for Painting

E 27 Method for Spectrographic Analysis of Zinc and Zinc Alloys by the Solution-Residue Technique

E 29 Recommended Practice for Indicating Which Places of Figures Are to be Considered Significant in Specified Limiting Values

E 47 Method for Chemical Analysis of Zinc Die-Casting Alloys

E 376 Recommended Practice for Measuring Coating Thickness by Magnetic-Field or Eddy-Current (Electromagnetic) Test Methods

2.2 *Military Standards*

MIL-STD-129 Marking for Shipment and Storage

MIL-STD-163 Steel Mill Products, Preparation for Shipment and Storage

2.3 *Federal Standard*

Fed. Std. No. 123 Marking for Shipments (Civil Agencies)

2.4 *American National Standard*

ANSI/ASME B32.3M Preferred Metric Sizes for Flat Metal Products

2.5 *Other Document*

GF-1 Standard Practice for Determination of Cerium and Lanthanum Compositions in Galfan Alloy (5% Al-0.4% La-0.4% Ce- Bal SHG ZN).*

(* Available from
International Lead Zinc Research Organization, Inc.
2525 Meridian Parkway
P.O. Box 12036
Research Triangle Park, NC 27709-2036

3. Terminology

3.1 Description of Terms

3.1.1 Chemical Treatment - a passivating chemical treatment normally applied to coatings to retard the formation of white corrosion products during shipment and storage. However, the inhibiting characteristics of the treatment are limited and if a shipment is received wet, the material should be used or dried immediately.

3.1.2 Commercial Quality (CQ) - a term applied to sheet steel intended for applications where material is subjected to bending or moderate forming.

3.1.3 Differentially Coated - metallic-coated sheet steel having a specified 'coating designation' on one surface and a significantly different 'coating designation' on the other surface. The single side relationship of either specified 'coating designation' is the same as shown in NOTE 1 of Table 1 regarding uniformity of coating.

3.1.4 Drawing Quality (DQ) - a term applied to sheet steel intended for fabrication of parts where drawing or severe forming may be involved.

3.1.5 Drawing Quality, Special Killed (DQSK) - a term applied to sheet steel intended for fabrication of parts where particularly severe drawing or forming may be involved or essential freedom from aging is required.

3.1.6 Extra Smooth (or Skin Passed) - a term applied to coated sheet steel which is skin passed to impart a higher degree of smoothness than is normal for the as-coated product, as is needed for some critical painted surfaces.

3.1.7 Lock-forming Quality (LFQ) - a term applied to sheet steel intended for applications where the material is subjected to machine lock-forming.

3.1.8 Mill Phosphatized- sheet steel chemically processed by the producer to prepare the surfaces for immediate painting without further treatment except normal cleaning (see Practices D 2092). Since this is a surface treatment only, all other characteristics of the coating remain unchanged. This sheet is normally produced to all coating designations in Table 1.

3.1.9 Oiling - a coating applied to metallic-coated sheet, alone or in addition to Chemical Treatment, for further protection against the onset of storage corrosion. If Chemical Treatment is undesirable because of further processing such as phosphatizing or painting, an oil coating offers protection during shipment storage. The oil coating is intended to be a corrosion inhibitor only and not a rolling or drawing lubricant.

3.1.10 Structural (Physical) Quality (SQ) - a term applied to sheet steel intended for applications where mechanical properties are specified or required. Such properties or values include those indicated by tensile, hardness, or other commonly accepted mechanical tests.

3.1.11 Wiped - coated sheet produced by wiping down molten Zn-5Al coating as it leaves the pot. This product has a light alloy coating and may have striations on the surface of the coating. With the Zn-5Al coating, wiping is employed to produce thinner coating thickness product and not a zinc-iron alloy coating as is the case with galvanized sheet.

3.2 Description of Terms Specific to this Standard

3.2.1 Minimized Coating Structure - a coating characterized by a finer metallurgical coating structure obtained by a treatment designed to restrict the formation of the normal coarse grain structure formed during solidification of the alloy coating.

3.2.2 Regular Coating Structure - the normal coating structure resulting from unrestricted grain growth during normal solidification of the alloy coating.

3.3 Abbreviations

3.3.1 MM - mischmetal.

3.3.2 Zn-5Al - Zinc-5% Aluminum.

3.3.3 Zn-5Al-MM - Zinc-5% Aluminum-Mischmetal.

3.3.4 Zn-5Al-Mg - Zinc-5% Aluminum-0.1% Magnesium.

4. Classification

4.1 The material is available in two *Types*, as follows:

4.1.1 *Type I* - zinc-5% aluminum-mischmetal (Zn-5Al-MM).

4.1.2 *Type II* - zinc-5% aluminum-0.1% magnesium (Zn-5Al-Mg).

4.2 The material is available in several *Qualities*, as follows:

4.2.1 Commercial Quality (CQ).

4.2.2 Lock-forming Quality (LFQ).

4.2.3 Drawing Quality (DQ).

4.2.4 Drawing Quality, Special Killed (DQSK).

4.2.5 Structural (Physical) Quality (SQ)

4.2.5.1 Structural Quality is available in several *Grades*, with differing chemical compositions and mechanical properties. See Table 4.

4.3 The material is available in several *Coating Designations*, or weights (thicknesses) of coating, as shown in Table 1.

4.3.1 The material is available with the same coating designations on both surfaces, or with *Differential Coating* designations.

4.4 The material is available in two coating *Classes*, or *Structures*, as follows:

4.4.1 Class A - Minimized Coating Structure

4.4.2 Class B - Regular Coating Structure

4.4.3 Class C - Wiped Coating (Type I only)

5. Ordering Information

5.1 Orders for material to this specification should include the following information, as necessary, to adequately describe the desired product.

5.1.1 Name of material (steel sheet, metallic-coated),

5.1.2 Specification designation, including issue (A 875-xx),

5.1.3 Type (I or II),

5.1.4 Quality (Commercial Quality, Drawing Quality, etc.).

5.1.4.1 For Structural Quality, also state Grade (A, B, etc.),

5.1.5 Coating Designation (see Table 1),

5.1.5.1 If differential coatings are required, so state, giving both coating designations,

5.1.6 Class of coating structure (Class A - Minimized, etc.),

5.1.7 Extra Smooth (if required),

5.1.8 Chemical Treatment (if required),

5.1.9 Whether oiling is required or permitted,

5.1.10 Mill Phosphatized (if required),

5.1.11 Dimensions, if cut lengths (show thickness, width, and length),

5.1.12 Coil-size requirements, if coils (show maximum outside diameter [OD], acceptable inside diameter [ID], and maximum weight),

5.1.13 Whether heat analysis is required (see 7.1.2),

5.1.14 Application (show part identification and description), and

5.1.15 Special requirements (if any).

NOTE 1 - Typical ordering descriptions are as follows:

Steel Sheet, Metallic-coated, ASTM A 875-87, Type I, Commercial Quality, Coating Designation GF115, Class A - Minimized Coating Structure, Chemically Treated, Oiled, 0.040 by 34 by 117 in., for Stock Tanks.

Steel Sheet, Metallic-coated, ASTM A 875M-8x, Type II, Structural Quality - Grade A, Coating Designation ZGF275, Class B - Regular Coating Structure, Chemically Treated, Not Oiled, Phosphatized, 1.00 by 900 mm by Coil, 1200 mm max OD, 600 mm ID, 9000 kg max, for Roof Deck.

6. Materials and Manufacture

6.1 The base metal shall be made by the open-hearth, basic-oxygen, or electric-furnace process.

6.2 The material shall be metallic-coated by the hot-dip process.

6.3 The material shall be produced to thickness only, with the thickness expressed as either decimal inches or millimeters. The thickness of the sheet includes both the base steel and the coating.

6.4 For purposes of determining conformance with this specification, values shall be rounded to the nearest unit in the right-hand place of figures used in expressing the limiting values in accordance with the rounding method of Recommended Practice E 29.

7. Chemical Requirements

7.1 The heat analysis of the base metal shall conform to the requirements shown in Table 2.

7.1.1 An analysis of each heat or cast of steel shall be made by the producer to determine the content of each of the elements specified or restricted in Table 2.

7.1.2 When requested, the heat or cast analysis shall be reported to the purchaser or his representative.

7.2 Product analysis may be made by the purchaser on finished material. The chemical analysis so determined shall be in accordance with the requirements of Table 2, subject to the additional tolerances in Table 3.

7.2.1 Product analysis is not technologically suited to capped orrimmed steels due to the nonuniform character of their chemical composition, and therefore, the tolerances in Table 3 do not apply. Product analysis is appropriate on these steels only when misapplication is apparent.

7.2.2 Product analysis for phosphorus or sulfur is not technologically appropriate because of segregation of these elements in all types of steel. Product analysis is appropriate only when misapplication is apparent.

7.2.3 Samples for product analysis shall be drillings through stripped areas in sufficient numbers to represent the coil or lift adequately. At least three pieces shall be selected, but if the product of more than one mill lift or coil is involved, six pieces shall be selected.

7.3 Coating Bath Analysis

7.3.1 The bath metal used in continuous hot-dip alloy coating of Type I shall meet the chemical composition limits specified in Specification B 750.

7.3.2 The bath metal used in the continuous hot-dip alloy coating of Type II shall conform to the requirements in Table 21.

7.4 Methods of Analysis

7.4.1 Base metal - the test methods shall be in accordance with Methods A 751.

7.4.2 Coating bath metal - suitable test methods, such as Methods E 47 and E27, shall be used. In case of dispute, the results secured by Method E 47 shall be the basis of acceptance.

7.4.2.1 A standard practice for X-ray fluorescence spectrometry for the determination of cerium and lanthanum in a zinc-5% aluminum-mischmetal has been established by the International Lead Zinc Research Organization as *Standard Practice GF-1*.

8. Mechanical Requirements (Base Metal)

8.1 Bend - For all qualities other than Structural (Physical) Quality, the bend test specimen shall be capable of being bent through 180° flat on itself in any direction without cracking of the base metal on the outside of the bent portion. Bend test requirements for Structural Quality are shown in Table 5.

8.2 Tensile Properties - Steel ordered as Structural (Physical) Quality shall conform to the limits prescribed in Table 4.

8.3 When base metal mechanical properties are required, they shall be determined by the methods described in Methods A 370.

8.4 In determining the base metal mechanical properties, base metal thickness shall be measured after stripping the coating from the ends of the specimen contacting the grips of the tension testing machine, before testing.

8.5 Base Metal Test Specimens

8.5.1 Test specimens shall be prepared from finished material.

8.5.2 Specimens for base metal tension tests shall be taken longitudinal and shall be selected and machined to the standard rectangular tension test specimen with 2 in. gage length as outlined in Methods A 370.

8.5.3 Specimens for base metal bend tests shall be as free as possible of burrs. Filing or machining to remove burrs is permitted. If any specimen develops a flaw it shall be discarded and a new specimen substituted. Cracks of the base metal developing at the edge of the specimen or coarse grain developing at the lineof the bend shall be disregarded.

9. Coating Requirements

9.1 Coating Weight (mass):

9.1.1 The weight (mass) of coating shall conform to the requirements for triple and single-spot minimum checks prescribed in Table 1 for the specific coating designation. The weight (mass) of coating is the total amount on both sides of a sheet, except in the case of a differential coating where the coating weight (mass) on each side is one-half that prescribed in Table 1. For example, a GF90/GF30 [ZGF275/ZGF90] differentially coated sheet would have a nominal coating weight of 0.45 oz/sq ft [138 g/sq m] on one side and 0.15 oz/sq ft [45 g/sq m] on the opposite side of the same sheet.

9.1.2 When the purchaser wishes to make tests to ascertain compliance with this specification for coating weight (mass) on a lot of any specific item of coated sheet, the procedure to be employed is as outlined in Methods A 90 in conjunction with the sampling procedure provided in 9.1.3, 9.1.4, and 9.1.5, except that for this specification it refers to Zn-5Al eutectic-alloy coated sheet instead of to galvanized sheet.

9.1.3 Triple-Spot Test - The triple-spot test shall be made in accordance with the procedure of Methods A 90. The result shall consist of the average of determinations from the three specimens cut from the test sheet or sample piece as provided in 9.1.5. Material 18 in. [450 mm] and under in width is normally produced by slitting from wider width coils and therefore is subject to the single-spot test only. Material slit after leaving the producer's works is subject to the single-spot test only.

9.1.4 Single-Spot Test - The minimum check limit by the singlespot test shall be that one of the triple-spot test bearing the lightest coating, or the purchaser may select a single specimen taken from any part of the test sheet providing it is taken within the boundaries outlined in 9.1.5. For material narrower than 2.25 in. [50 mm], the test specimen length shall be chosen to give an area of approximately 5 sq. in. [3000 sq mm].

9.1.5 Test specimens for coils and cut lengths coated in coils shall be taken from a sample piece approximately 1 ft. [300 mm] in length by the as-coated width. For the triple-spot test, one specimen shall be cut from the middle of the width and one from each side not closer than 2 in. [50 mm] from the side edge.

9.1.6 Coating Thickness Measurements with Magnetic Gages - A reasonable estimate of weight (mass) of coating may be obtained by comparing coating thickness measurements made with magnetic gages to to values shown in Table 1. An accuracy of ±15% in determining the thickness may be realized by following the recommended practice for magnetic instruments described in Recommended Practice E 376. This test may be used as a basis for acceptance but rejection shall be governed by the weight (mass) of coating tests described in 9.1.1 through 9.1.5.

9.1.7 Coating Thickness Measurements with X-Ray Fluorescence Type Gages - The referee method to be employed shall be as agreed upon between producer and consumer. Where no method is specified, the X-ray fluorescence method, in accordance with Method A 754, shall be employed provided the data are available and evidence of appropriate calibration control is maintained. Where the X-ray fluorescence data are not available or no evidence of calibration control is maintained, the method described in Methods A 90 shall be employed.

9.2 Coating Bend Test:

9.2.1 Coated sheet designated by prefix "GF" or "ZGF" shall be capable of being bent through 180° in any direction without flaking of the coating on the outside of the bend only. The coating bend test inside diameter shall have a relation to the thickness of the specimen as prescribed in Table 6. Flaking of the coating within 0.25 in. [6 mm] of the edge of the bend specimen shall not be cause for rejection.

9.2.2 Additional coating bend test requirements for structural (physical) quality steels are found in Table 5.

9.2.3 Coating bend test specimens shall be 2 to 4 in. [50 to 100 mm] wide. The specimen shall be cut not less than 2 in. [50 mm] from the edges of the test sheet.

10. Retests

10.1 If one test fails for either base metal or coating, two more tests shall be taken at random from the same lot of any specific item. Both retests must conform to the requirements of the specifications; otherwise, the lot shall be rejected.

10.2 When the percent of elongation is less than the specified minimum and any part of the fracture is outside the middle half of the gage length as scribed before the test, the test shall be discarded and a retest shall be permitted.

11. Dimensions and Tolerances

11.1 Applicable dimensions and tolerances are listed in Tables 1 and 7 through 20. Appendix X1 lists preferred dimensions for material ordered to SI units.

12. Workmanship

12.1 Cut lengths shall have a workmanlike appearance and shall not have defects of a nature or degree for the grade and quality ordered that will be detrimental to the fabrication of the finished part.

12.2 Coils may contain some abnormal imperfections which render a portion of the coil unusable since the inspection of coils does not afford the producer the same opportunity to remove portions containing imperfections as in the case of cut lengths.

13. Product Information

13.1 Sheet in coils is subject to coil "breaks" when coiled to a smaller inside diameter than is compatible to the thickness of the sheet. To minimize this condition, sheet heavier than 0.0291 in. [0.75 mm] should be ordered with a minimum 24 in. [600 mm] inside diameter and a minimum of 20 in. [500 mm] for thinner material. In further processing, such as slitting, the material should not be rewound on a smaller inside diameter than received.

14. Packaging, Marking, and Loading

14.1 It is common practice to use the methods of packaging as listed in Recommended Practices A 700.

14.2 The purchaser may specify requirements other than 14.1.

14.3 Abrasion during transit may have an effect on the appearance of coated steel. This condition is minimized if the product is oiled.

14.4 When specified in the contract or order, and for direct shipments to the U.S.A. Government, when Level A is specified, preservation, packaging, and packing shall be in accordance with the Level A requirements of MIL-STD-163. Marking for shipment shall be in accordance with Fed. Std. No. 123 for civil agencies and MIL-STD-129 for military agencies.

15. Inspection

15.1 The producer shall afford the purchaser's inspector all reasonable facilities to assure the inspector that material is being produced in compliance with the specification. Unless otherwise specified, all inspection and tests, except product analysis, shall be made at the producer's works prior to shipment. Such inspection or sampling shall be made concurrently with the producer's regular inspection and test operations unless it causes interference with normal operations or is otherwise specified.

15.2 Responsibility for Inspection - Unless otherwise specified in the contract or purchase order, the producer is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the producer may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the purchaser.

15.3 The purchaser reserves the right to perform any of the inspections set forth herein where such inspections are deemed necessary to assure that supplies and services conform to the prescribed requirements.

16. Rejection and Rehearing

16.1 Unless otherwise specified, any rejection shall be reported to the producer within a reasonable time after receipt of material by the purchaser.

16.2 Material that is reported to be defective subsequent to the acceptance at the purchaser's works shall be set aside, adequately protected, and correctly identified. The producer shall be notified as soon as possible so that an investigation may be initiated.

16.3 Samples that are representative of the rejected material shall be made available to the producer. In the event that the producer is dissatisfied with the rejection, he may request a rehearing.

Tables 1 through 20, and X1 - Revise, as necessary, to delete "-MM" where it appears in the term "Zn-5Al-MM" in table titles and column headings.

In NOTE 3 to Table 1, replace "AWWW (AWWWM)" with "A 875 (A 875M)".

Add Table 21 as follows:

TABLE 21 Chemical Requirements, Coating Bath, Type II[A]

Element	Composition, Wt. %
Aluminum	4.5 - 6.2
Magnesium	0.05 - 0.15
Others, total, max[B]	0.01
Zinc[C]	Remainder[C]

[A] By agreement between purchaser and supplier, analysis may be required and limits established for elements not specified in the table.
[B] Except Fe and Zn
[C] For information only. Quantitative determination of this element is not required.

Abnormal corrosion of the pipes for bath exchange

Sumitomo Metal Ind., Ltd.

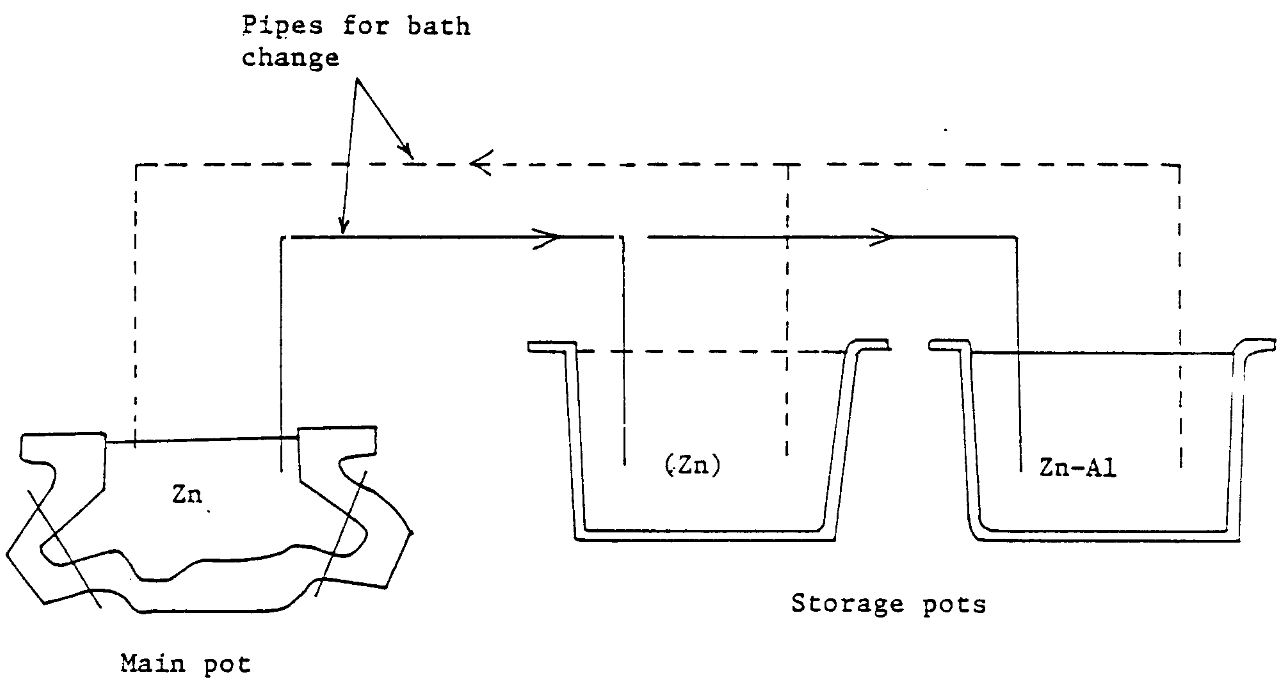
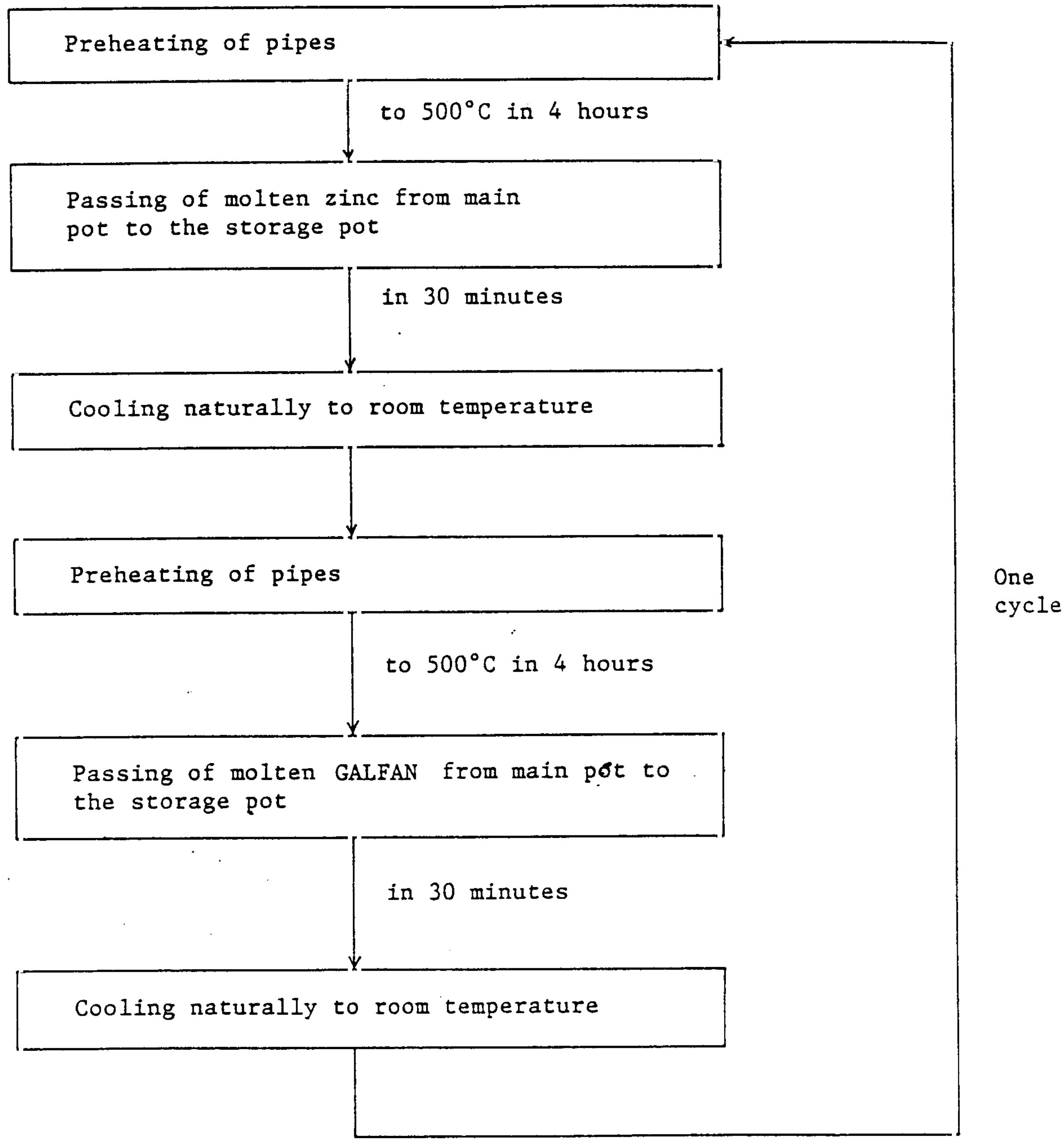


Fig. 1 Bath changing equipment



Leakage occurred after 2-1/2 cycles.

Fig. 2 Bath exchange practice

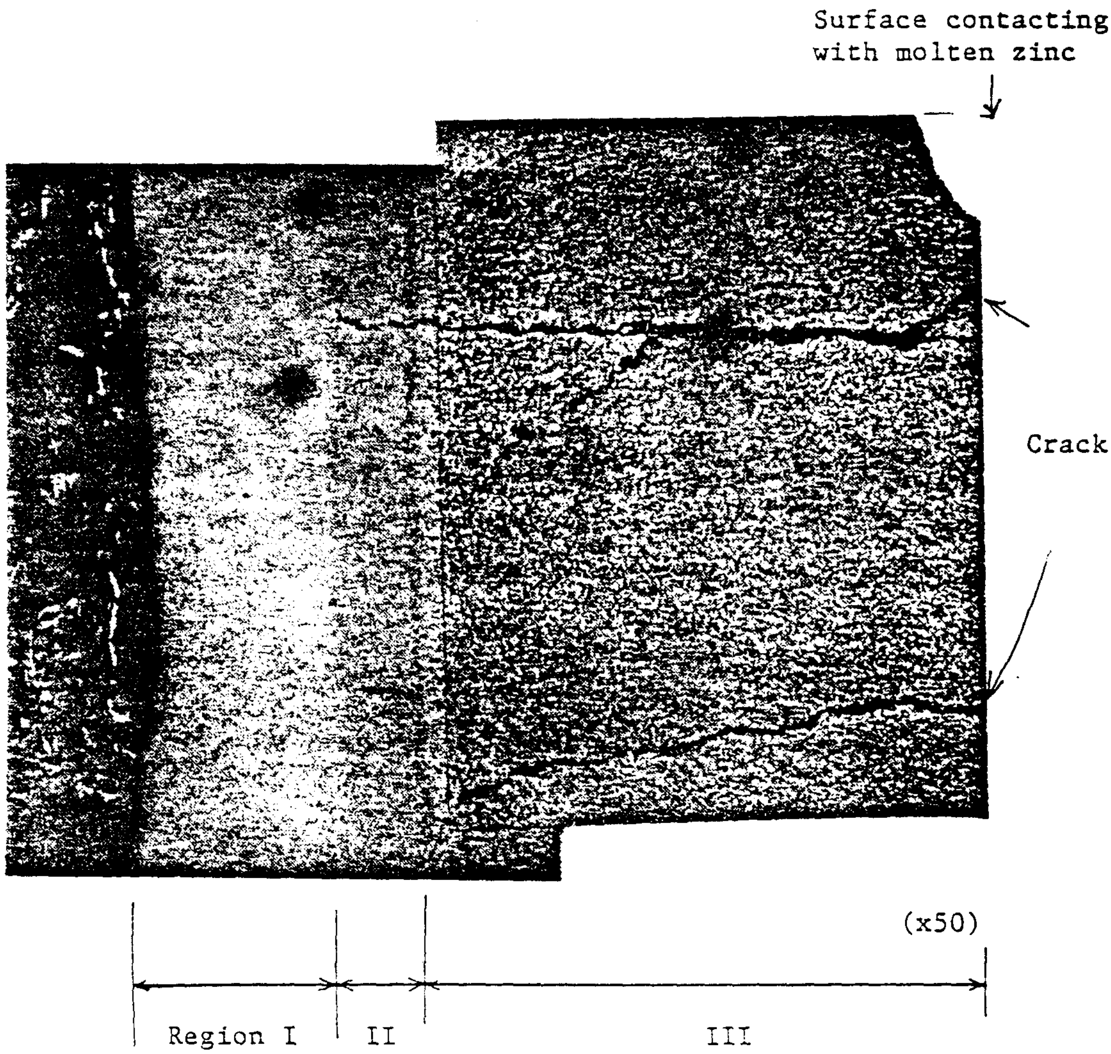
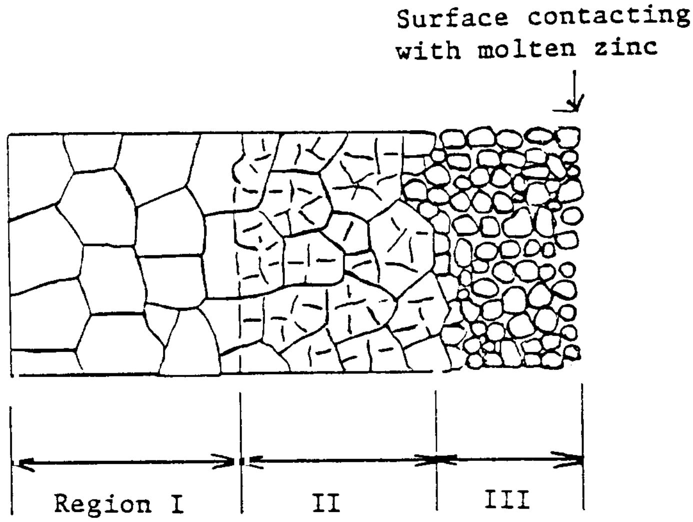


Photo. 1 Cross section of cracks

- Cracks appear along the γ boundary -



EDAX			
Cr:	18 ∿ 19%	18 ∿ 21%	18%∿
Ni:	6 ∿ 9%	0 ∿ 3%	∿0
Zn:	0	5 ∿ 8%	8 ∿ 10%

Region I: Base metal
II: Degenerated
III: Degenerated-layer -granular

Fig. 3 Schematic of corrosion of pipes for bath exchange

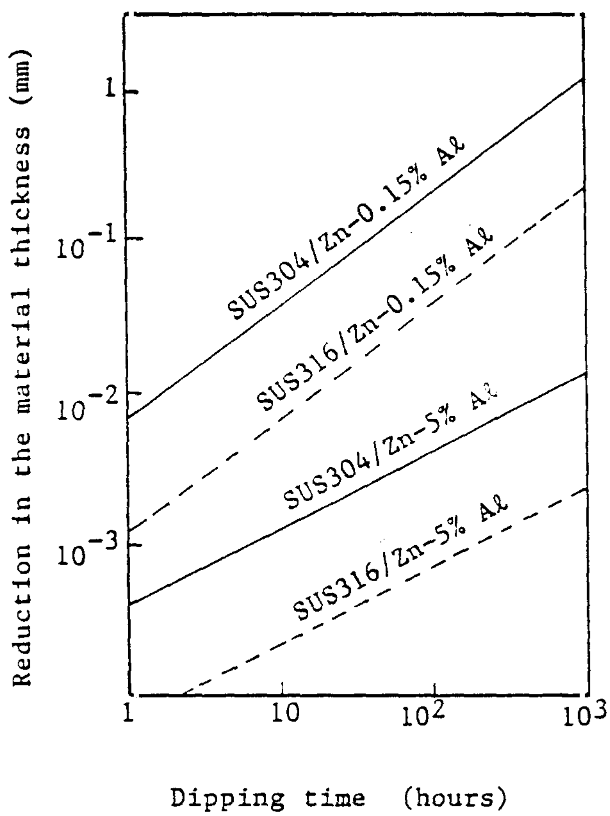
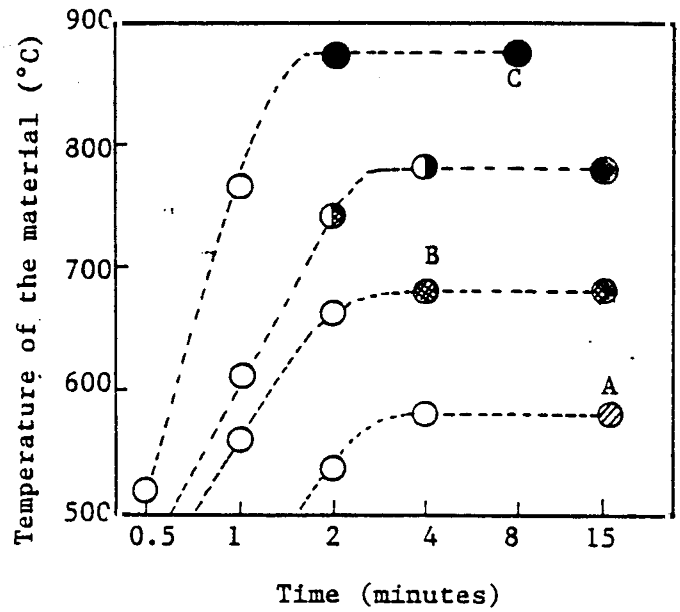


Fig. 4 Reduction in the material thickness by simple dipping in a bath

- Temperature: 460°C



○ η-Zn

⊘	Fe: 8 ∿ 13%	Ni: 1 ∿ 2%
	Cr: 2 ∿ 4%	Zn: balance
⊛	Fe: 15 ∿ 17%	Ni: 2%
	Cr: 2 ∿ 4%	Zn: balance
●	Fe: 65 ∿ 73%	Ni: 0 ∿ 3%
	Cr: 18 ∿ 21%	Zn: balance

Fig. 5 Formation of the diffusion layer in SUS 304 as time passes: Isothermal heating model where zinc is overlaid on the surface of SUS 304 beforehand - Observation points

A: 15 minutes, 580°C
B: 4 min., 680°C
C: 8 min., 880°C

Point A

Point B

Point C

Photo. 2 Microscopic picture of the alloyed layer at each observation point

-A: Zinc is rich (Fe: 8 ~13%, Ni: [illegible] ~ 2%, Cr: 2 ~ 4%
Zn: balance)

B: Partially no nickel regions are observed (Fe: 15 ~17%, Ni: 2%, Cr: 2 ~4%
Zn: balance)

C: No nickel regions are developed (Fe: 65 ~73%, Ni: 0 ~3%, Cr: 18 ~21%
Zn: balance)

Dipping in the zinc bath for 2 hours

↓

Heating at 580°C, 680°C and 780°C for 15 minutes

↓

Dipping in the zinc bath for 2 hours

↓

Dipping in the GALFAN bath for 2 hours

↓

Heating at 580°C, 680°C and 780°C for 15 minutes

↓

Dipping in the GALFAN bath for 2 hours

Fig. 6 Simulation for real heating cycle: cyclic heating model

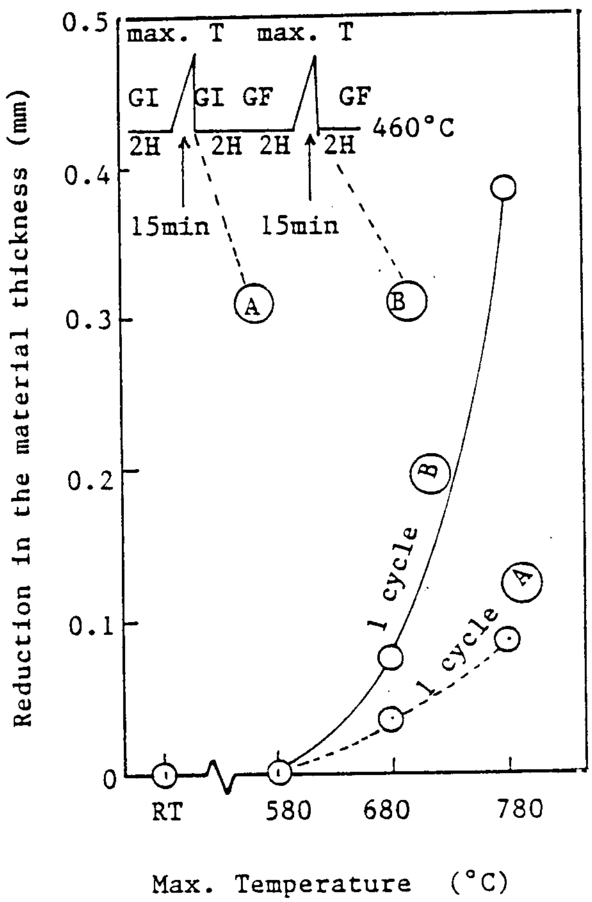


Fig. 7 Reduction in the material thickness (SUS304) as the maximum temperature is changed:
Cyclic heating model, where the material is dipped in a bath

- A : after the zinc bath is transported

B : after the galfan bath is transported

Conclusion

1. The corrosion of bath exchange pipe is caused and accelerated by the high preheating temperature.

2. If the exchange is repeated, the rate of corrosion is increased and the more at higher temperatures, that is at above 680°C.

1. CORROSION EVOLUTION IN GALFAN COATING AS A FUNCTION OF :
   - AL CONTENT (4.0 4.6 4.8 5.2)
   - COOLING RATE (5 AND 30°C/SEC)

   COMPARED TO GALVANIZED, GALVALUME AND ALUMINIZED.
   EVALUATION THROUGH OUTDOOR EXPOSURE AND ACCELERATED TESTS.

2. CHECK CATHODIC PROTECTION AT BARE EDGES.
   MICROSTRUCTURES OF EARLY 1985 PROGRAM AFTER 1 YEAR ATMOSPHERIC EXPOSURE.

3. REMOVAL AND ANALYSIS OF SHEETS INVOLVED IN THE PROGRAM "ASTM SPECIFICATIONS CONCERNING THE AL CONTENT OF GALFAN", AFTER 1 YEAR OF OUTDOOR EXPOSURE IN INDUSTRIAL SITE. PARAMETERS ARE : % AL AND COOLING RATE.

4. REMOVAL AND ANALYSIS OF FIRST ZIEGLER TRIAL SHEETS (RESULTS AFTER 5 YEARS EXPOSURE).

5. INTERCRISTALLINE CORROSION GENERATED BY LEAD.
   REMOVAL AND ANALYSIS OF THE PILOT LINE COATED WIRES AFTER 1 YEAR OF OUTDOOR EXPOSURE IN SEVERE MARINE AND INDUSTRIAL SITES.
   PARAMETERS ARE : PB CONTENT, BATH COMPOSITION.

6. INTERCRISTALLINE CORROSION OF COATED INDUSTRIAL WIRES.
   PROGRAM TO BE INITIATED.
   6.1. ATMOSPHERIC EXPOSURE (LONG TERM)
        3 EXPOSURE SITES (SEV. MAR., IND., RUR.)
   6.2. ACCELERATED TESTS : KEST, H.C., SST.

7. GRAY PATINA : GALFAN PAINTABILITY AFTER PATINA FORMATION.

8. RING TEST TO EVALUATE THE LUBRICANT BEHAVIOR OF GALFAN COATINGS.

9. PICK-UP OF GALFAN DURING THE REDRAWING OF WIRES :
   TO BE COMPARED : SINGLE DIP, DOUBLE DIP AND GALVANIZED.

ILZRO MEETING (PITTSBURGH)

C.R.M. RESEARCH RESULTS.

1. SHEET CORROSION STUDIES
   - 1.A. EDGE CORROSION AND CATHODIC PROTECTION
   - 1.B. ASTM SPECIFICATIONS OF AL CONTENT OF GALFAN
   - 1.C. GREY PATINA EVOLUTION.

2. WIRE CORROSION STUDIES
   - 2.A. EFFECT OF PB CONTENT OF GALFAN (LAB. PRODUCTS)
   - 2.B. COMPARISON OF GALVA AND GALFAN (1, 2 DIP) (IND. PRODUCTS)
   - 2.C. ACCELERATED TESTS (SST, HC) OVER INDUSTRIAL WIRES.

3. RING TESTS.

4. PROPOSALS.

CHARACTERISTICS OF COATINGS USED IN THE LONG TERME ATMOSPHERIC EXPOSURE
INITIATED IN EARLY 1985

	N°	COATING	PRODUCT	EXPOSURE SITE	THICKNESS (II)	STEEL GAGE	CHROM MG/
	ZA1	GALFAN	ZIEGLER (C6)	IND	20	0,60	0
	ZA2	GALFAN	ZIEGLER (C9)	IND	15	0,35	0
A	ZA3	GALFAN	PHENIX WORKS	4	17	0,70	0
B	ZA4	GALFAN	ZIEGLER	4	15	1,00	20
C	ZA5	GALFAN	ZIEGLER	4	21	1,00	20
D	ZA6	GALFAN	ZIEGLER	4	18	2,35	20
E	ZA7	GALFAN	HOESCH	4	31	0,60	10
F	ZA8	GALFAN	F.F.M.	4	26	0,60	20
G	Z 9	GALVANIZED	PHENIX WORKS	4	20	0,70	15
	Z 10	GALVANIZED	PHENIX WORKS	IND	20	0,80	20
H	AZ11	ALUZINC	ARBED	4	20	0,63	0

(I) NOTE : M/N : MINIMIZED / NORMAL SPANGLE S : TEMPER ROLLED
E : FULLY EUTECTIC STRUCTURE

(II) PERMASCOPE MEASUREMENTS.

CORROSION DATA (1 YEAR EXPOSURE) OF LONG TERM PROGRA

				CORROSION RATE
N°	COATING	RURAL	INDUSTRIAL	MARINE
ZA1	ZIEGLER C6		1,40	
ZA2	ZIEGLER C9		1,40	
ZA3	PHENIX WORKS	0,90	1,20	2,30
ZA4	ZIEGLER	0,60	1,00	1,80
ZA5	ZIEGLER	0,70	1,20	2,10
ZA6	ZIEGLER	0,75	1,40	2,70
ZA7	HOESCH	0,80	1,20	2,70
ZA8	FFM	0,45	0,80	1,80
Z 9	PHENIX WORKS	0,95	1,70	2,40
Z10	PHENIX WORKS		2,40	
AZ11	ARBED	0,35	0,60	1,10

LONG TERM EXPOSURE PROGRAM (EARLY 85)

EDGE STATE (% RED RUST) AFTER 1 YEAR OF OUTDOOR EXPOSURE

SITES :	SEV.MAR.	MAR.	IND.	RUR.
GALFAN A(I)	0	0	50	50
GALFAN D(II)	60	50	50	70
GALFAN F	0	0	50	50
GALVA	0	0	50	50
ALUZINC	100	100	-	100

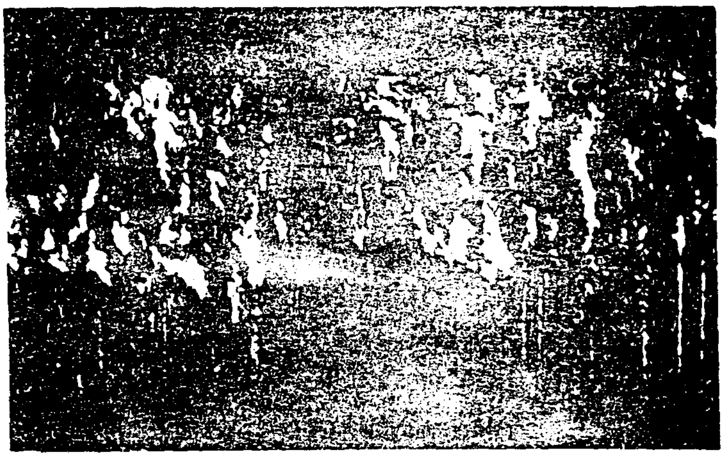
(I) % AL = 3.8

(II) GAGE = 2.35 MM

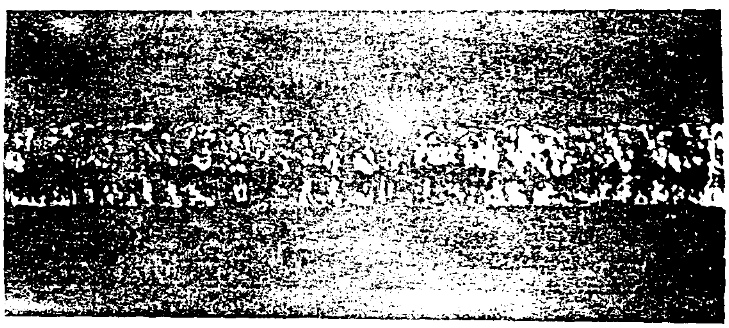
LONG TERM EXPOSURE PROGRAM (EARLY 85)

EDGE STATE (20x) AFTER 1 YEAR OF OUTDOOR EXPOSURE
IN RURAL SITE.

COATING



GALFAN D
(GAGE = 2.35MM)

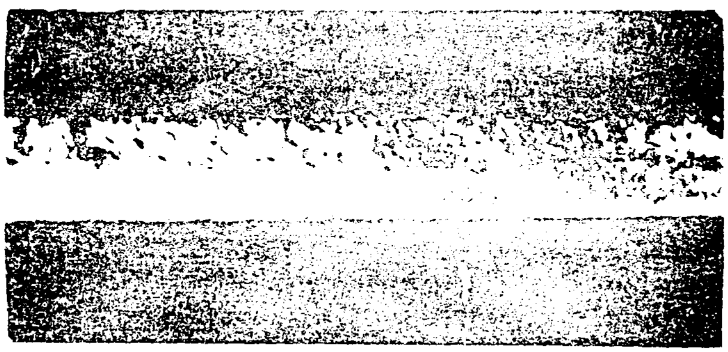


GALFAN F

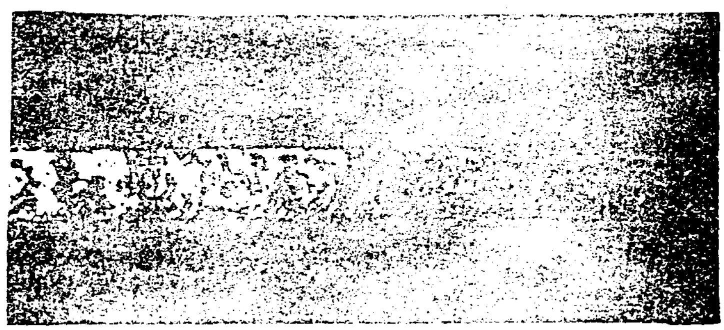
LONG TERM EXPOSURE PROGRAM (EARLY 85)

EDGE STATE (20x) AFTER 1 YEAR OF OUTDOOR EXPOSURE
IN RURAL SITE.

COATING

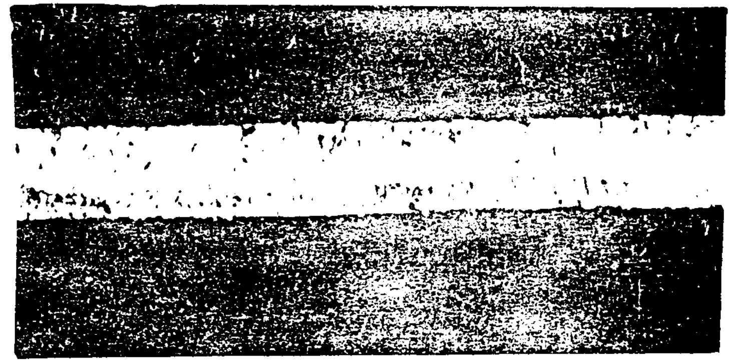


GALVA

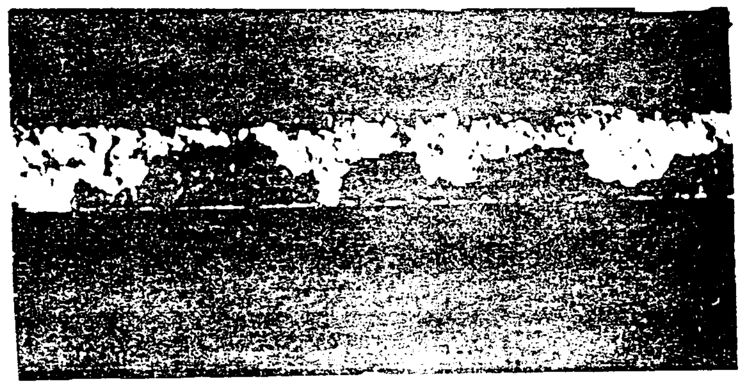


ALUZINC

COATING



GALFAN F

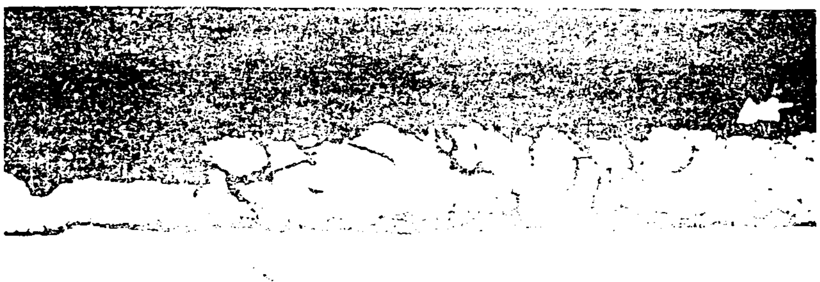


ALUZINC

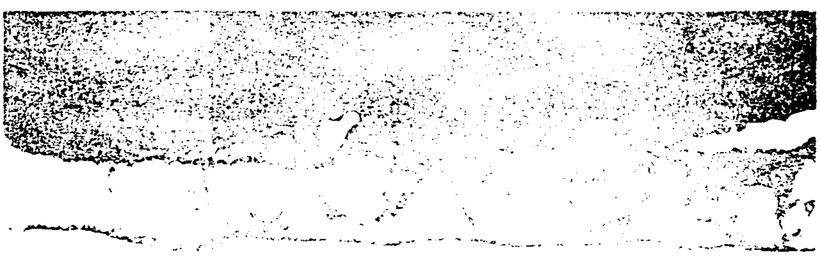
LONG TERM EXPOSURE PROGRAM (EARLY 85). EDGE EFFECT

MICROSTRUCTURES OF GALFAN A (FRONT VIEW-500x) AFTER 1 YEAR OF OUTDOOR EXPOSURE

EXPOSURE SITES



SEV. MAR.



INDUST.

RURAL

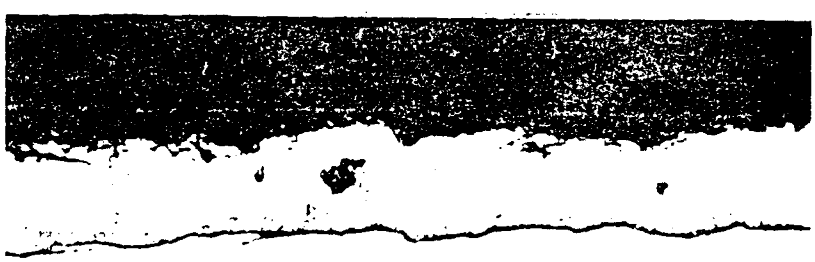
LONG TERM EXPOSURE PROGRAM (EARLY 85). EDGE EFFECT

MICROSTRUCTURES OF GALFAN D (FRONT VIEW-500x) AFTER 1 YEAR OF OUTDOOR EXPOSURE

EXPOSURE SITES

SEV. MAR.

INDUST.

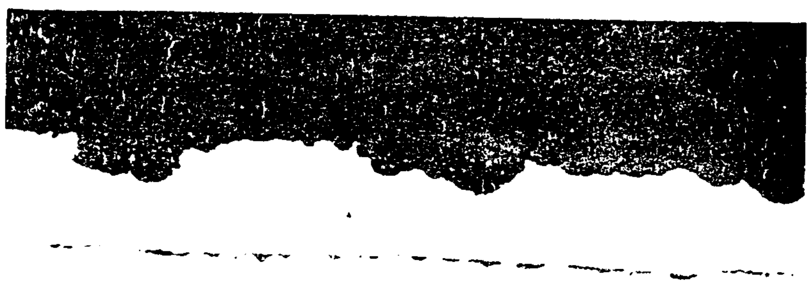


RURAL

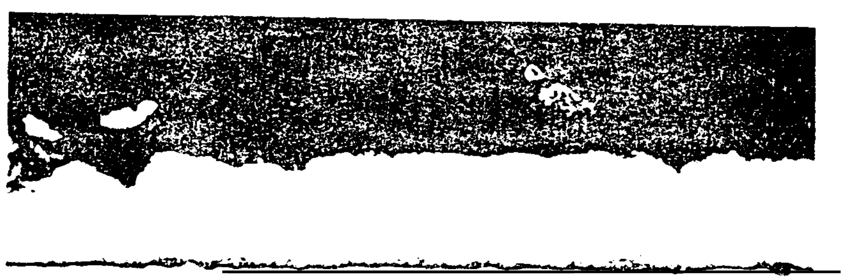
LONG TERM EXPOSURE PROGRAM (EARLY 85). EDGE EFFECT

MICROSTRUCTURES OF GALFAN F (FRONT VIEW-500x) AFTER 1 YEAR OF OUTDOOR EXPOSURE

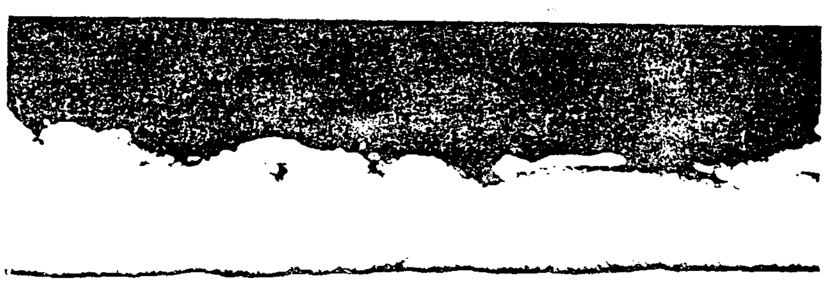
EXPOSURE SITES



SEV. MAR.



INDUST.

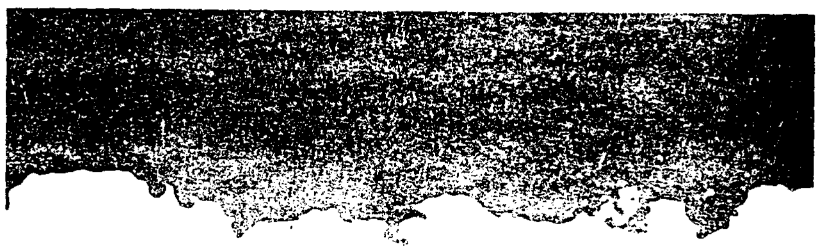


RURAL

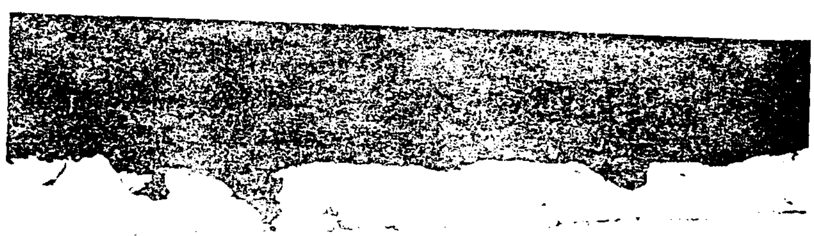
LONG TERM EXPOSURE PROGRAM (EARLY 85). EDGE EFFECT

MICROSTRUCTURES OF GALVA (FRONT VIEW-500x) AFTER 1 YEAR OF OUTDOOR EXPOSURE

EXPOSURE
SITES



SEV. MAR.



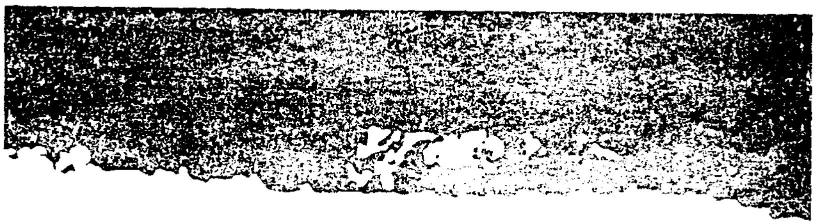
INDUST.

RURAL

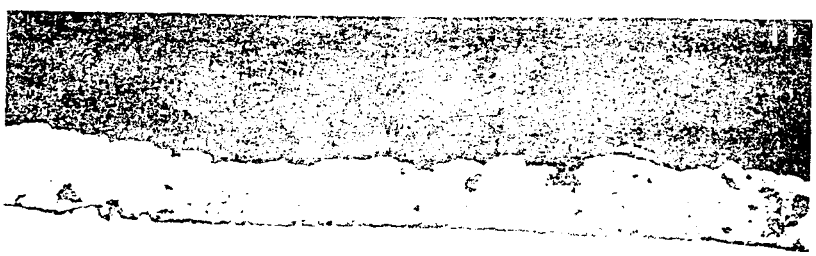
LONG TERM EXPOSURE PROGRAM (EARLY 85). EDGE EFFECT

MICROSTRUCTURES OF ALUZINC (FRONT VIEW-500x) AFTER 1 YEAR OF OUTDOOR EXPOSURE

EXPOSURE SITES



SEV. MAR.



RURAL

LONG TERM ATMOSPHERIC EXPOSURE PROGRAM OF LABORATORY GALFAN SHE

SITE : INDUSTRIAL

ENTRY DATE : 01/86

BATH TEMPERATURE : 440°C

IMMERSION TIME : 5 SEC.

BATH COMPOSITIONS (% AL) : 4.7
5.2
5.2 + SI (30 PPM)
6.2

COOLING RATES : 5°C/SEC
20°C/SEC

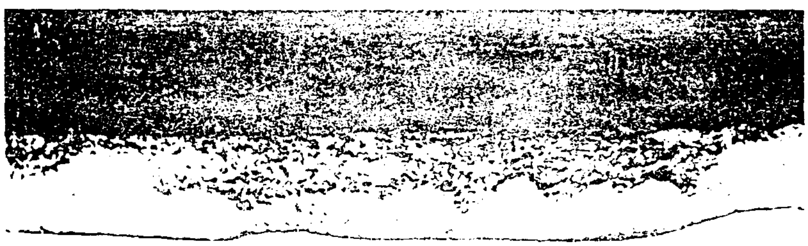
PURPOSES :
- EVALUATION OF THE CORROSION RESISTANCE AT THE LIMIT AS AL COMPOSITIONS.
- TEST THE INFLUENCE OF SILICON CONTENT OF GALFAN (AT EU TIC COMPOSITION) (INGOT CONTENT IN SILICON = 150 PPM).

GALFAN . ASTM SPECIFICATIONS

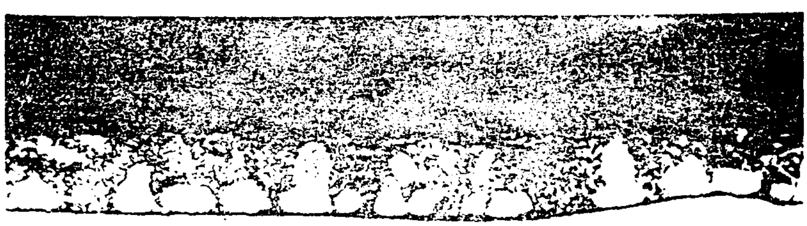
MICROSTRUCTURES (500 x) BEFORE EXPOSURE

% AL : 4.7

COOLING



NC



RC

% AL : 5.2 + SI

<u>COOLING</u>

NC

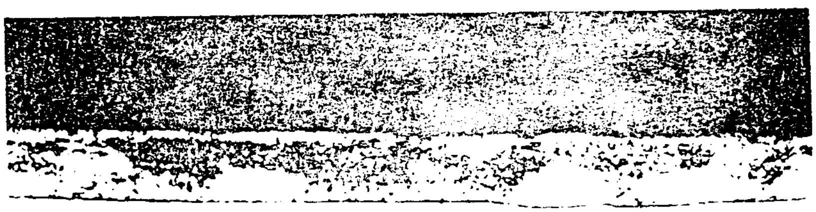
RC

GALFAN . ASTM SPECIFICATIONS

MICROSTRUCTURES (500 x) BEFORE EXPOSURE

% AL : 5.2

COOLING



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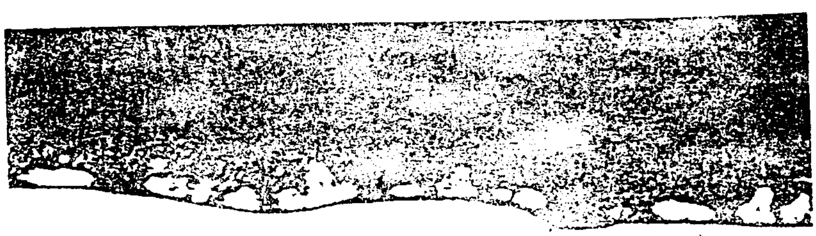
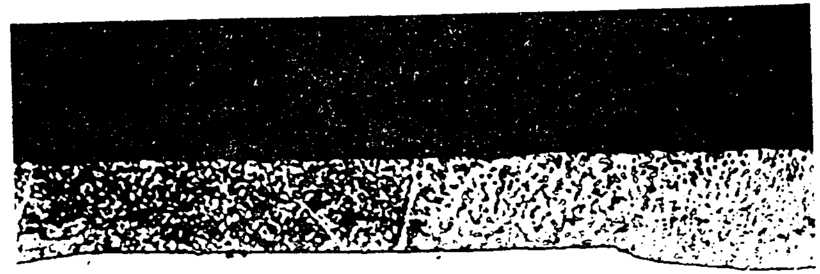


RC

MICROSTRUCTURES (500 X) BEFORE

% AL : 6.2

COOLING

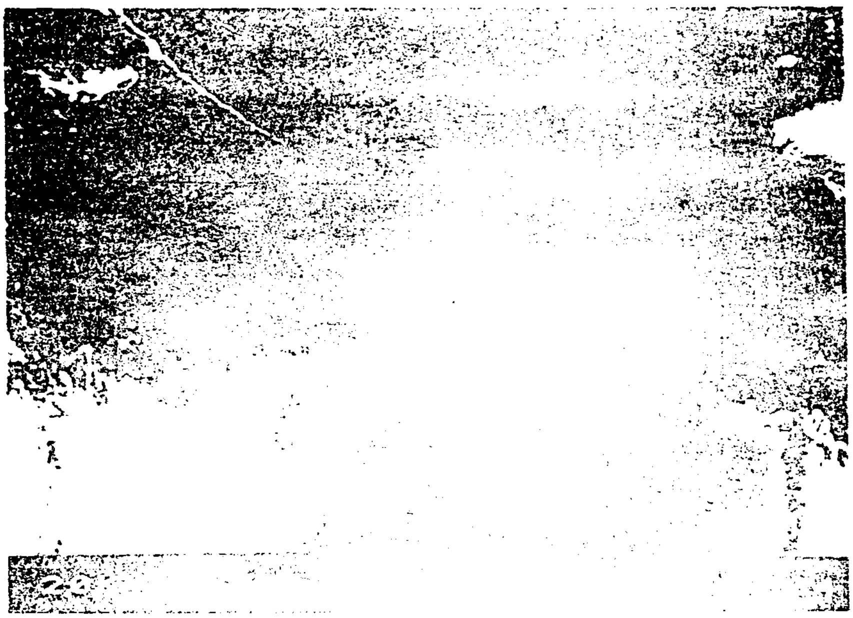


NC

RC

ASTM SPECIFICATION, %AL = 6.2

S.E.M. ANALYSIS (3500x) OF THE COATING SURFACE
BEFORE EXPOSURE



LIMIT ASTM AL IN GALFAN

THICKNESS LOSS AFTER 1 YEAR OF OUTDOOR EXPOSURE IN INDUSTRIAL S

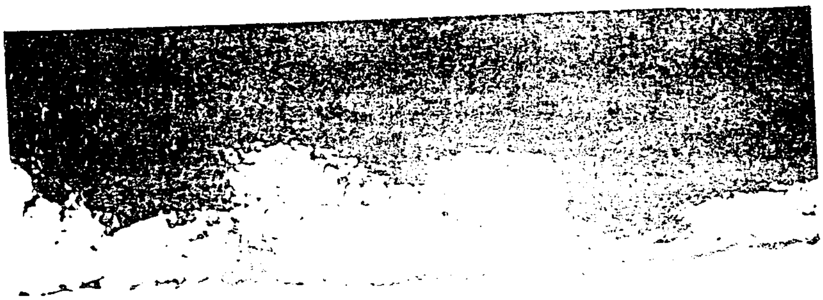
BATH (% AL)	4.7		5.2		5.2 + SI	
COOLING RATE	N	R	N	R	N	R
THICKNESS LOSS (μM)	3.6	3.3	3.3	3.2	3.5	3.6

NOTE : N/R ARE NORMAL (5°C/SEC) / RAPID (30°C/SEC) COOLING.

GALFAN ASTM SPECIFICATION , % AL = 4.7

MICROSTRUCTURES (500x) AFTER 1 YEAR OF OUTDOOR EXPOSURE IN INDUSTRIAL SITE

COOLING



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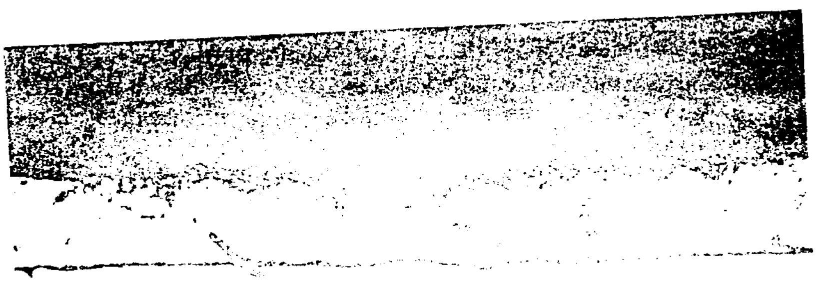
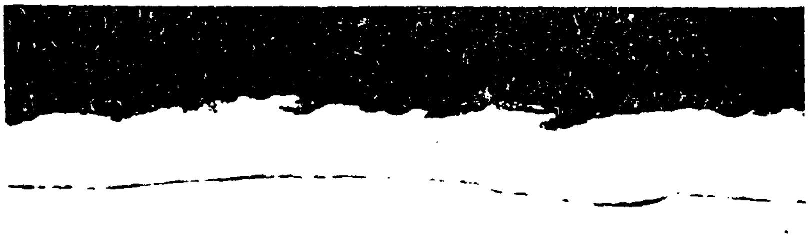


RC

GALFAN ASTM SPECIFICATION . % AL = 5.2 + SI

MICROSTRUCTURES (500x) AFTER 1 YEAR OF OUTDOOR EXPOSURE IN INDUSTRIAL SITE

COOLING



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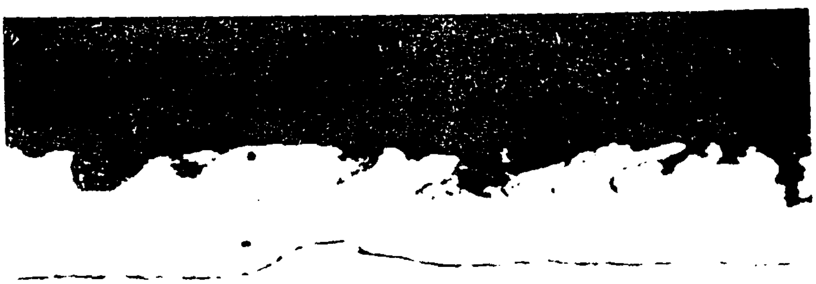
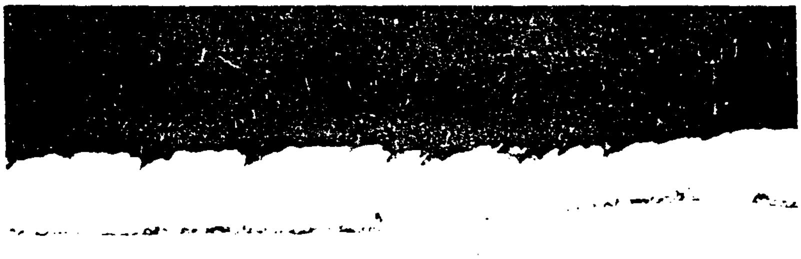


RC

GALFAN ASTM SPECIFICATION , % AL = 5.2

MICROSTRUCTURES (500x) AFTER 1 YEAR OF OUTDOOR EXPOSURE IN INDUSTRIAL SITE

COOLING



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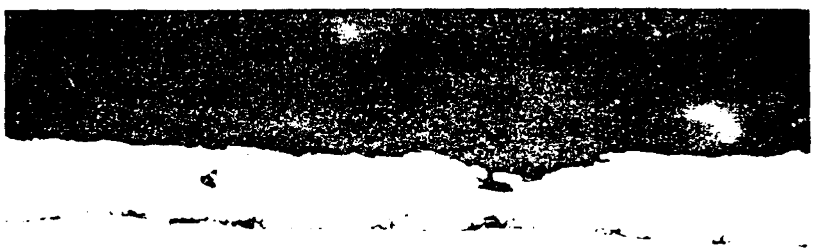


RC

GALFAN ASTM SPECIFICATION , % AL = 6.2

MICROSTRUCTURES (500x) AFTER 1 YEAR OF OUTDOOR EXPOSURE IN INDUSTRIAL SITE

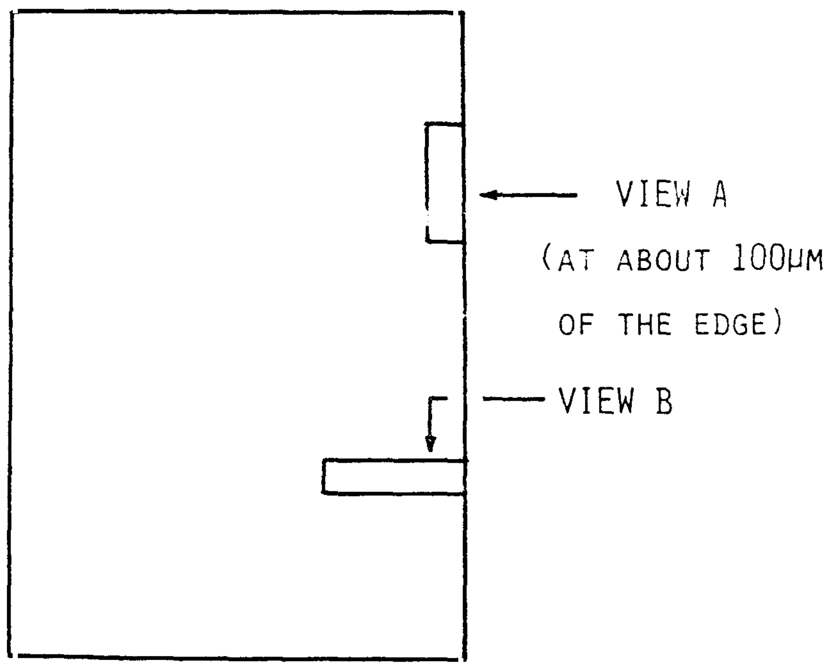
COOLING

NC

RC

GALFAN ASTM SPECIFICATIONS

SAMPLING FOR EDGE EFFECT EXAMINATION



GALFAN ASTM SPECIFICATIONS . % AL = 4.7

MICROSTRUCTURES (VIEW A AT 500x) AFTER 1 YEAR OF OUTDOOR EXPOSURE IN INDUSTRIAL SITE.

COOLING

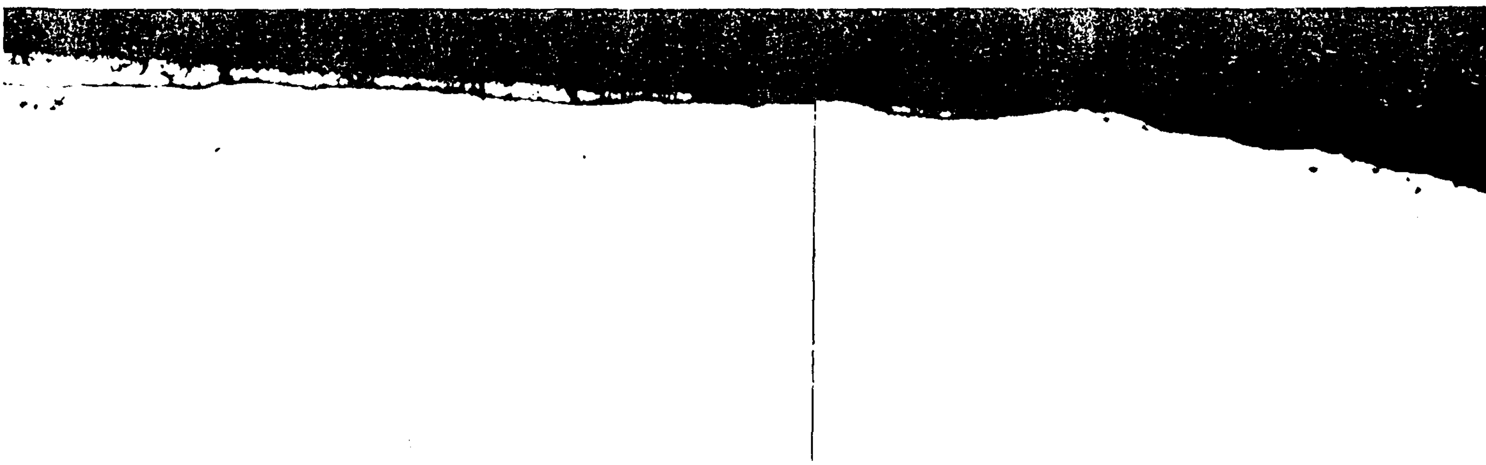
NC

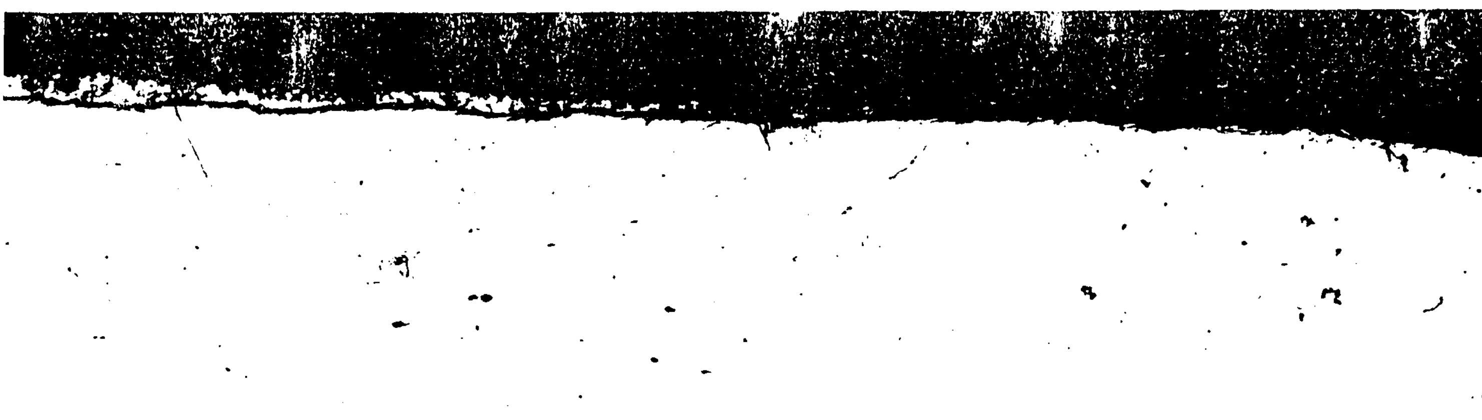
RC

GALFAN ASTM SPECIFICATIONS, EDGE EFFECT (VIEW B)

MICROSTRUCTURES AFTER 1 YEAR OUTDOOR EXPOSURE IN INDUSTRIAL SIT

(BOTH HAVE BEEN RAPIDLY COOLED)

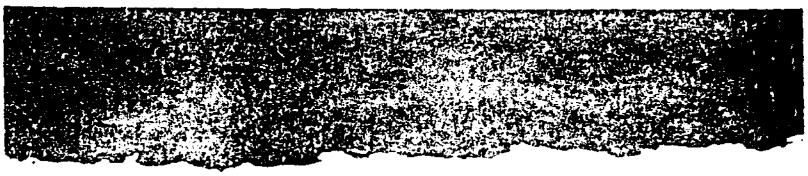




GALFAN ASTM SPECIFICATIONS . % AL = 6.2

MICROSTRUCTURES (VIEW A AT 500x) AFTER 1 YEAR OF OUTDOOR EXPOSURE IN INDUSTRIAL SITE.

COOLING



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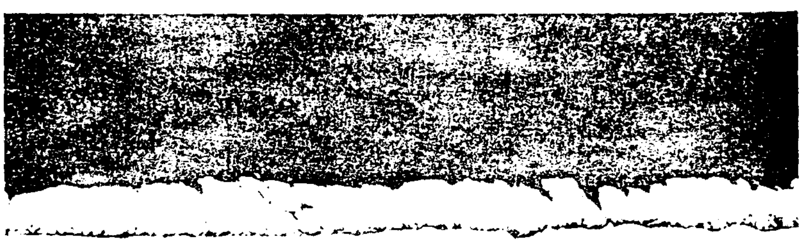


RC

OUTDOOR EXPOSURE OF GALFAN COATED WIRES.

EXPOSURE SITES : INDUSTRIAL
SEVERE MARINE

ENTRY DATE : 05/86

INDUSTRIAL SAMPLES :

	COATING	THICKNESS (µM)
A1	GALFAN (1 DIP)	34
A2	GALFAN (2x DIP)	44
A3	"	41
B	GALVANIZED	42

% AL OF GALFAN : 3.4 TO 3.8

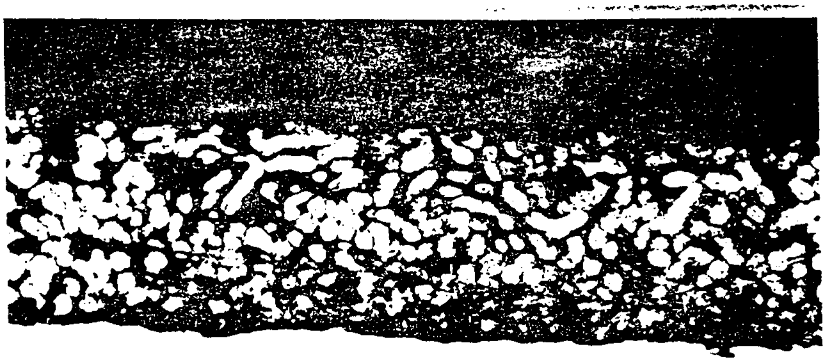
EVALUATION : - WEIGHT LOSS
- MICROSTRUCTURES
} AFTER 11 MONTHS OF OUTDOOR EXPOSURE

INDUSTRIAL WIRES

MICROSTRUCTURES (500x) BEFORE EXPOSURE

COATING : GALFAN

SINGLE DIP



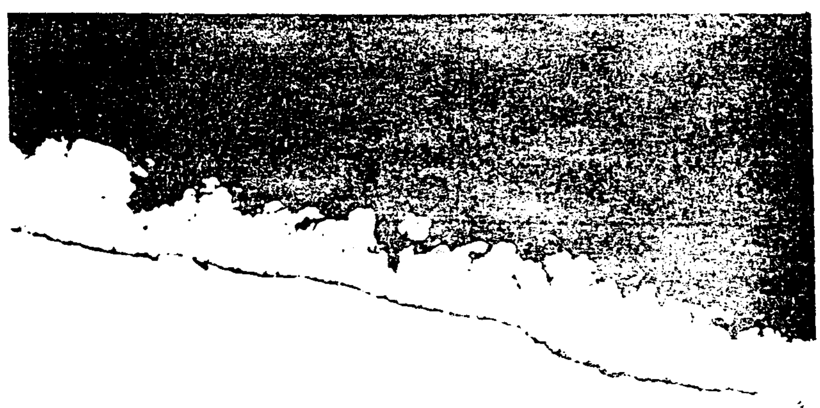
DOUBLE DIP

INDUSTRIAL WIRES

MICROSTRUCTURES (500x) AFTER 11 MONTHS OF OUTDOOR EXPOSURE IN SEVERE MARINE SITE

COATING

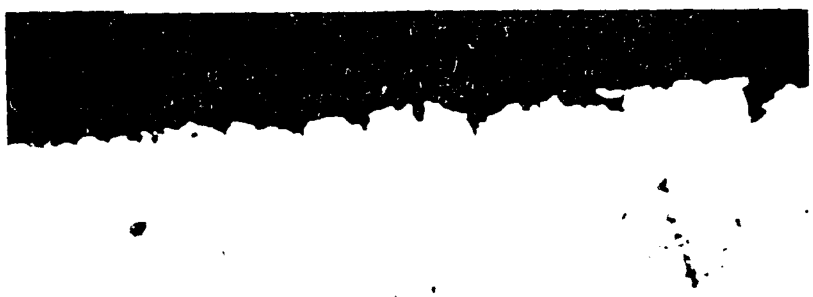
GALVA



GALFAN SINGLE DIP

INDUSTRIAL WIRES

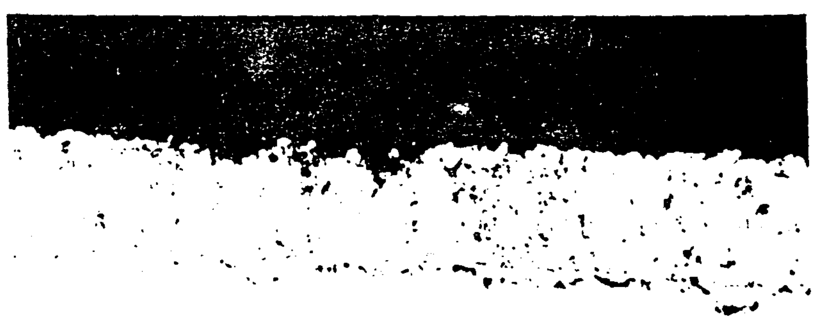
MICROSTRUCTURES (500 x) AFTER 11 MONTHS OF OUTDOOR EXPOSURE IN SEVERE MARINE SITE



<u>COATING</u>

GALFAN

DOUBLE DIP



~~ID~~ double dip

OUTDOOR EXPOSURE OF GALFAN COATED WIRES

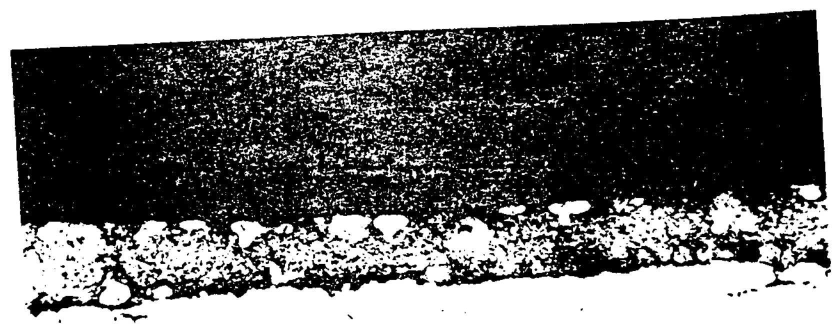
LABORATORY PRODUCTS	COATINGS' LEAD CONTENT (PPM) OF EXPOSED SAMPLES			
	SEVERE MARINE SITE			INDUSTR
BATH	L	M	H	L
GALFAN	50	90	160	50
ZN 5% AL	80	150	300	50
ZN 4.1% AL 0.03% MG	80	150	240	60
GALFAN + 50% BATH 3	60	135	160	60

NOTE : L/M/H : LOW, MEDIUM, HIGH LEAD CONTENT
WIRES DIAMETER = 1.6MM
12µM ≤ COATING THICKNESS ≤ 15µM

EVALUATION : - WEIGHT LOSS AFTER 11 MONTHS OF
- MICROSTRUCTURES. OUTDOOR EXPOSURE

Pb Level
(ppm)

50



180

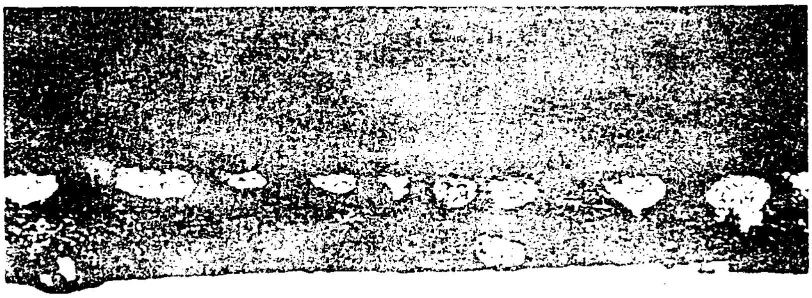
(250 x)

PILOT LINE WIRES

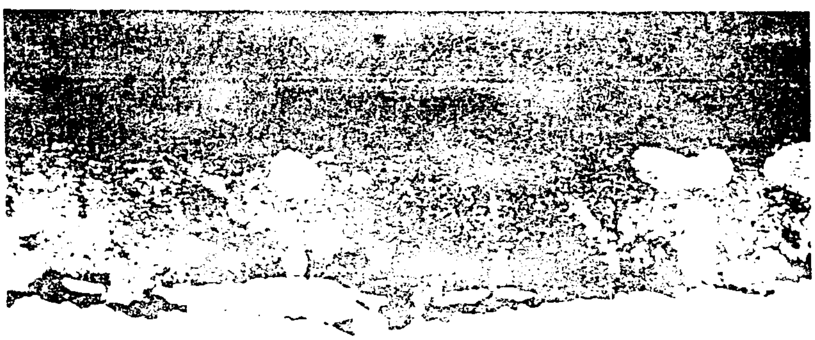
MICROSTRUCTURE (500 x) BEFORE EXPOSURE

COATING : ZN-5 AL

PB LEVEL (PPM)



50



350

PILOT LINE WIRES

MICROSTRUCTURE (500 x) BEFORE EXPOSURE

COATING : ZAMAK 3

PB LEVEL (PPM)

60

270

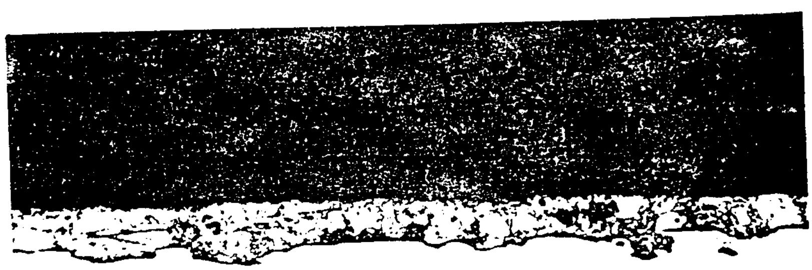
PILOT LINE WIRES

MICROSTRUCTURE (500 x) BEFORE EXPOSURE

COATING : ZAMAK 3 + GALFAN

PB LEVEL
(PPM)

60



270

GALFAN COATED WIRES. INFLUENCE OF LEAD CON

THICKNESS LOSS (μm) AFTER 11 MONTHS OF OUTDOOR E

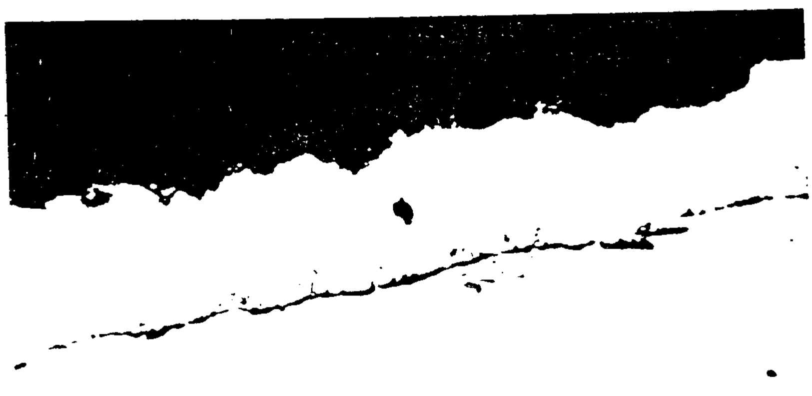
	SEVERE MARINE SITE			INDU
	L	M	H	L
GALFAN	6.8	6.6	5.8	3.0
Zn - 5% Al	6.5	5.8	7.9	3.7
Zn 4.1 Al 0.03 Mg	7.3	7.3	8.0	3.7
GALFAN + 50% BATH 3	7.0	6.7	7.0	3.7

NOTE : L/M/H ARE LOW / MEDIUM / HIGH LEAD CONTENT

<u>PILOT LINE WIRES - COATING : GALFAN</u>

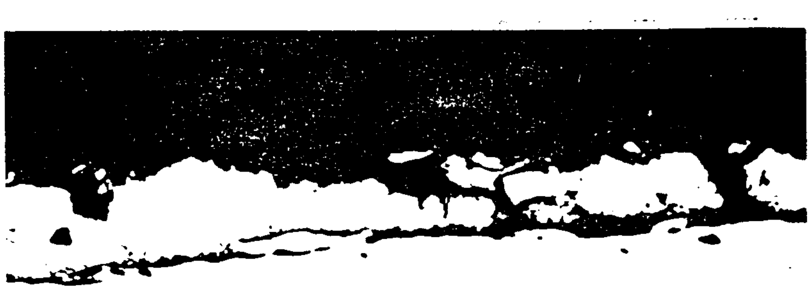
MICROSTRUCTURES (500x) AFTER 11 MONTHS OF OUTDOOR EXPOSURE IN SEVERE MARINE SITE.

PB LEVEL (PPM)



50

90

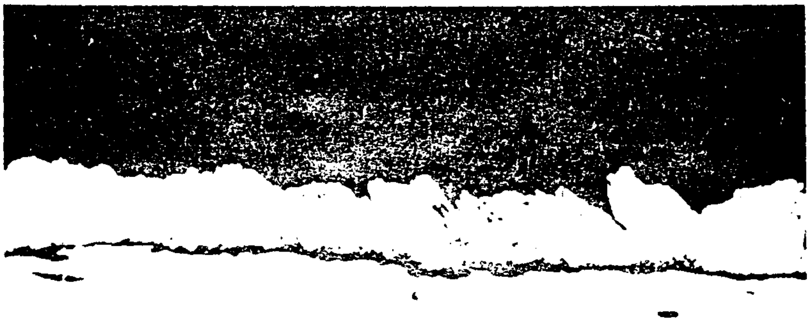


160

PILOT LINE WIRES - COATING : ZN.5 AL

MICROSTRUCTURES (500x) AFTER 11 MONTHS OF OUTDOOR EXPOSURE IN SEVERE MARINE SITE.

PB LEVEL (PPM)



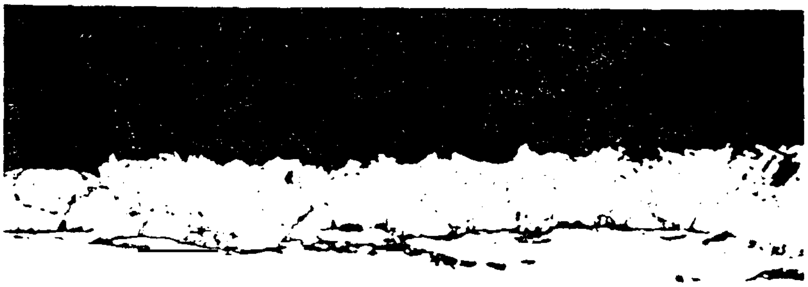
150

300

PILOT LINE WIRES - COATING : ZAMAK 3

MICROSTRUCTURES (500x) AFTER 11 MONTHS OF OUTDOOR EXPOSURE IN SEVERE MARINE SITE.

PB LEVEL (PPM)



80

150

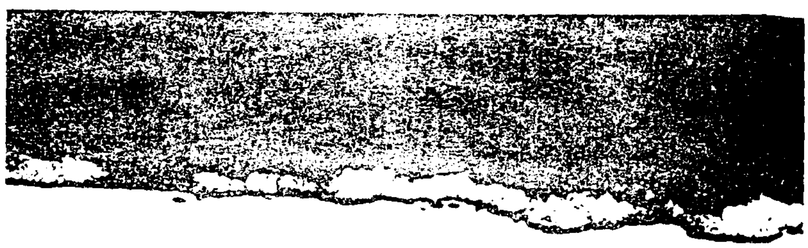
240

<u>PILOT LINE WIRES - COATING : ZAMAK 3 + GALFAN</u>

MICROSTRUCTURES (500x) AFTER 11 MONTHS OF OUTDOOR EXPOSURE IN SEVERE MARINE SITE.

PB LEVEL (PPM)

60



160

PILOT LINE WIRES - COATING : GALFAN

MICROSTRUCTURES (500x) AFTER 11 MONTHS OF OUTDOOR EXPOSURE IN INDUSTRIAL SITE.

PB LEVEL (PPM)

50

180

PILOT LINE WIRES - COATING : ZN.5 AL

MICROSTRUCTURES (500x) AFTER 11 MONTHS OF OUTDOOR EXPOSURE IN INDUSTRIAL SITE.

PB LEVEL (PPM)

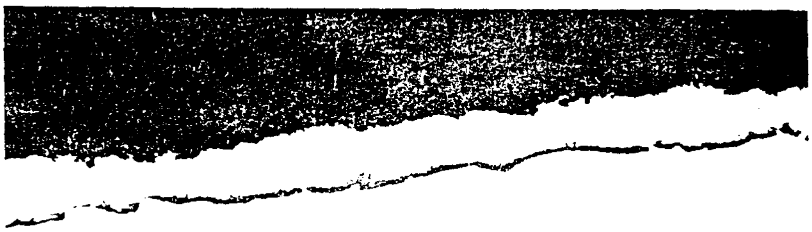
200

350

PILOT LINE WIRES - COATING : ZAMAK 3.

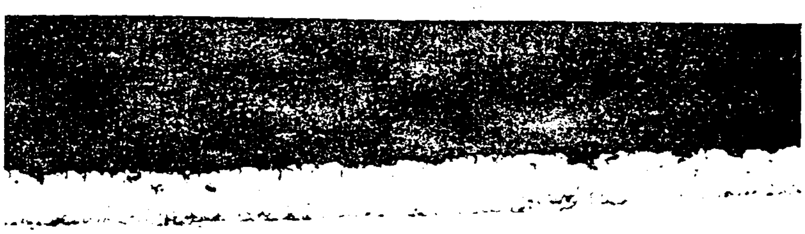
MICROSTRUCTURES (500x) AFTER 11 MONTHS OF OUTDOOR EXPOSURE IN INDUSTRIAL SITE.

Pb Level (ppm)



60

180



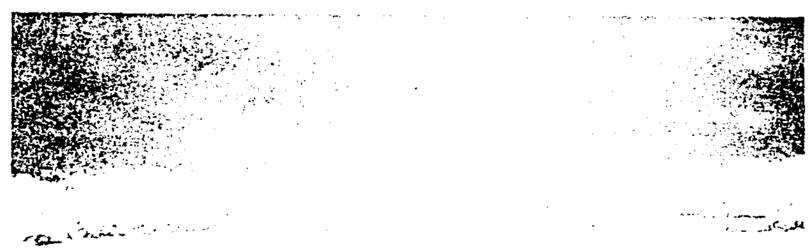
270

PILOT LINE WIRES - COATING : ZAMAK 3 + GALFAN.

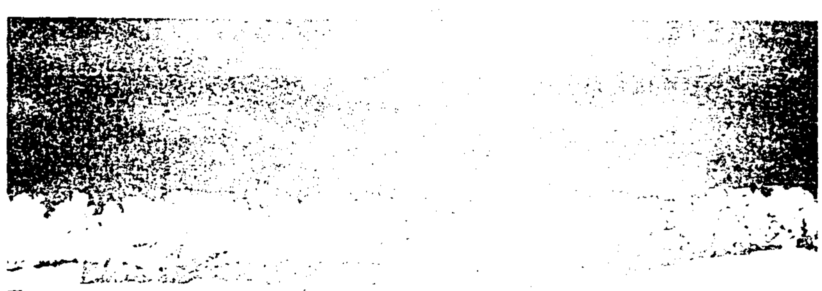
MICROSTRUCTURES (500X) AFTER 11 MONTHS OF OUTDOOR EXPOSURE IN INDUSTRIAL SITE.

PB LEVEL (PPM)

60



120



270

RESEARCH CONTINUATION : PROPOSALS

1. SHEETS :

CORROSION EVOLUTION IN GALFAN COATING AS A FUNCTION OF :

- AL CONTENT (4.0 4.6 4.8 5.2)
- COOLING RATE (5 AND 30°C/SEC)

GALFAN COATED SHEETS PERFORMED IN THE SIMULATION EQUIPMENT.

COMPARED TO INDUSTRIAL GALVANIZED GALVALUME AND ALUMINIZED.

EXPERIMENTATIONS ARE :

- SHORT TERM ATMOSPHERIC EXPOSURE (6 MONTHS, 1, 3, 5 YEARS) IN 3 SITES : SEV. MAR., IND. AND RUR.
- POLARISATION MEASUREMENTS (BEFORE EXPOSURE)
- ACCELERATED TESTS : H.C. SST, KEST.

CHARACTERISATION BY :

- WEIGHT LOSS (CrO_3)
- MICROSCOPY
- SCANNING (OF SURFACE AND CROSS-SECTION).

PROPOSALS (CONTINUED).

2. SHEETS : LONG TERM OUTDOOR EXPOSURE PROGRAM.
   CHARACTERISATION OF GALFAN COATINGS (INDUST. PRODUCTS) AFTER 3 YEARS OF OUTDOOR EXPOSURE (EARLY 88) :
   - WEIGHT LOSS (CrO_3)
   - MICROSCOPY
   - SCANNING (OF SURFACE AND CROSS SECTION).

3. SHEETS : SLIGHT HYPEREUCTIC STRUCTURES (% AL = 5.5 TO 6.0).
   PRODUCTS PERFORMED IN THE SIMULATION EQUIPMENT. ITS CHARACTERISATION BY MICROSCOPY AND SCANNING.
   QUALITATIVE EVALUATION OF CORROSION RATE (AND EVOLUTION THROUGH ACCELERATED TESTS.
   COMPARISON WITH GALFAN.

4. SHEETS : INFLUENCE OF MAGNESIUM OVER CORROSION INHIBITION. PARAMETERS ARE :
   - AL CONTENT : 4.0 4.6 5.2
   - TWO LEVELS OF MG (ONLY FOR % AL = 5.2).
   PERFORMED IN THE SIMULATION EQUIPMENT.
   EVALUATION OF CORROSION RATE THROUGH ACCELERATED TESTS AND OUTDOOR EXPOSURE.
   CHARACTERIZATION : SEE ITEM 2.

5. SHEETS : S.E.M. CROSS-SECTIONNAL ANALYSIS OF CORRODED AREAS IN GALFAN, GALVALUME AND ALUMINUM COATINGS, AFTER 1 AND 5 YEARS OF OUTDOOR EXPOSURE IN ALL SITES.

PROPOSALS (CONTINUED).

6. INDUSTRIAL WIRES (REF. : B1, B2, B3, B4, FZ, FG) : LONG TERM ATMOSPHERIC EXPOSURE IN 3 SITES (SEV. MAR., INDUST., RURAL).
   RESULTS OF KESTERNICH TEST FOR 4, 7 AND 10 DAYS OF EXPOSURE.

7. PILOT LINE WIRES : LONG TERM ATMOSPHERIC EXPOSURE PROGRAM.
   SITES : SEVERE MARINE AND INDUSTRIAL.

8. INDUSTRIAL WIRES : GALFAN DOUBLE DIP (REF. : A2, A3, B2, FG).
   CHEMICAL ANALYSIS OF THE AL DISTRIBUTION BETWEEN THE GALFAN COATING AND THE INTERMETALLIC LAYER.
   CROSS SECTIONNAL SCANNING ANALYSIS OF THE INTERMETALLIC LAYER IN ORDER TO CHECK THE HOMOGENEITY OF THE AL DISTRIBUTION.

- STUDY OF DIFFERENT POST-TREATMENTS

- ATMOSPHERIC EXPOSURE
  URBAN SITE OF LIEGE (23/06/86)

- RATE OF DARKENING
  LIGHT REFLECTANCE MEASUREMENTS
  TWICE A MONTH

NICKEL ELECTROLESS PLATING

SUBSTRATE : GALFAN HOESCH (CAMPAIGN N° 3)
MINIMUM SPANGLE - UNCHROMATED
SKIN-PASSED - UNOILED

DEGREASING : TRICHLORETHYLENE

SOLUTION : electrolyte composition
$NiSO_4$ 25 G/L
NaH_2PO_2 25 G/L
$CH_3CHOHCOOH$ (85%) - LACTIC ACID 30 g/l
P_H = 4.5 (NH_4OH)
T = 98°C
t ≃ 1 min.

THICKNESS : ≃ 1μ

ANTI-PATINA SOLUTION

SUBSTRATE : GALFAN HOESH

SOLUTION : BRUGAL T3MG-50% (PROCOAT)

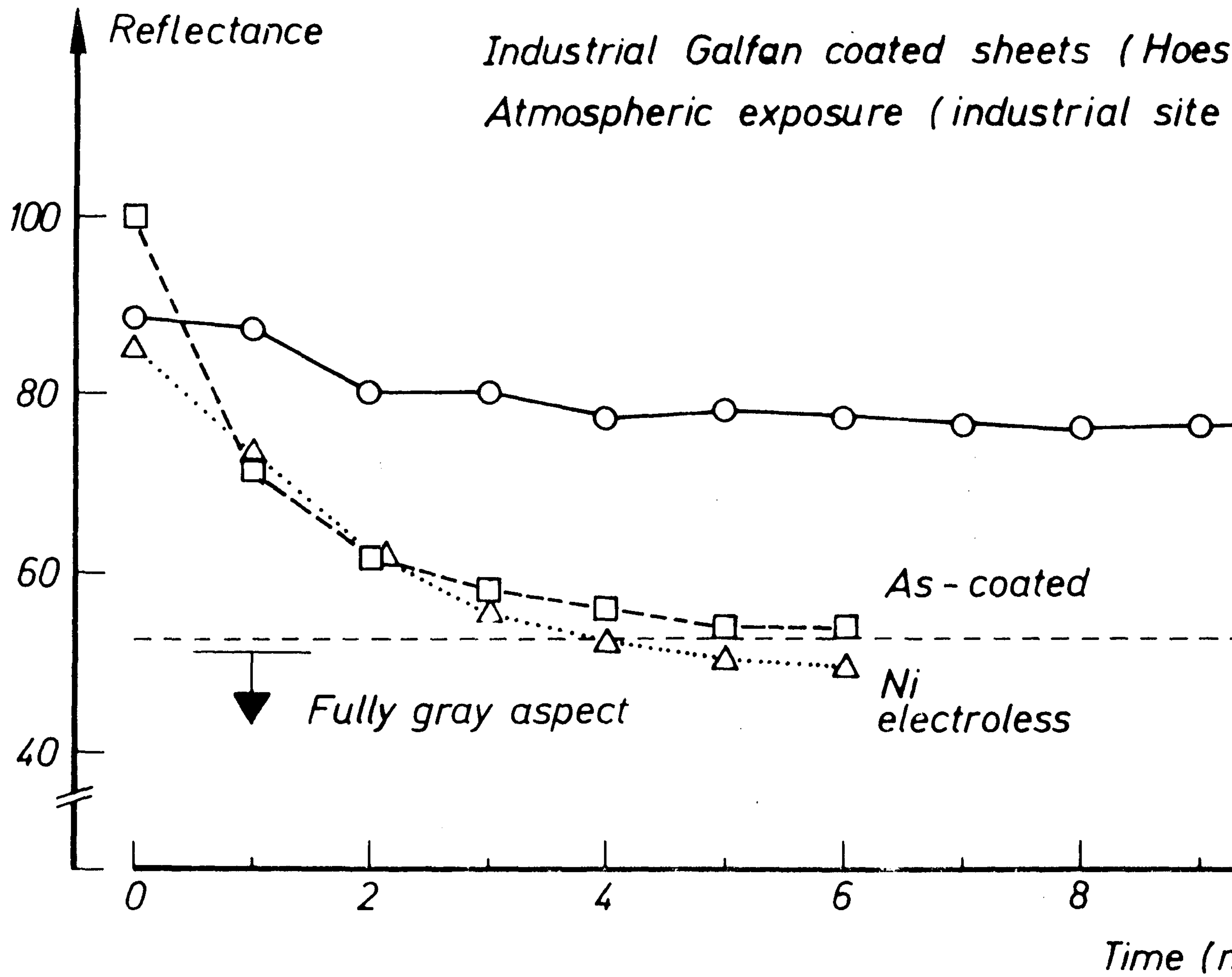
APPLICATION : SPRAY OR DIP

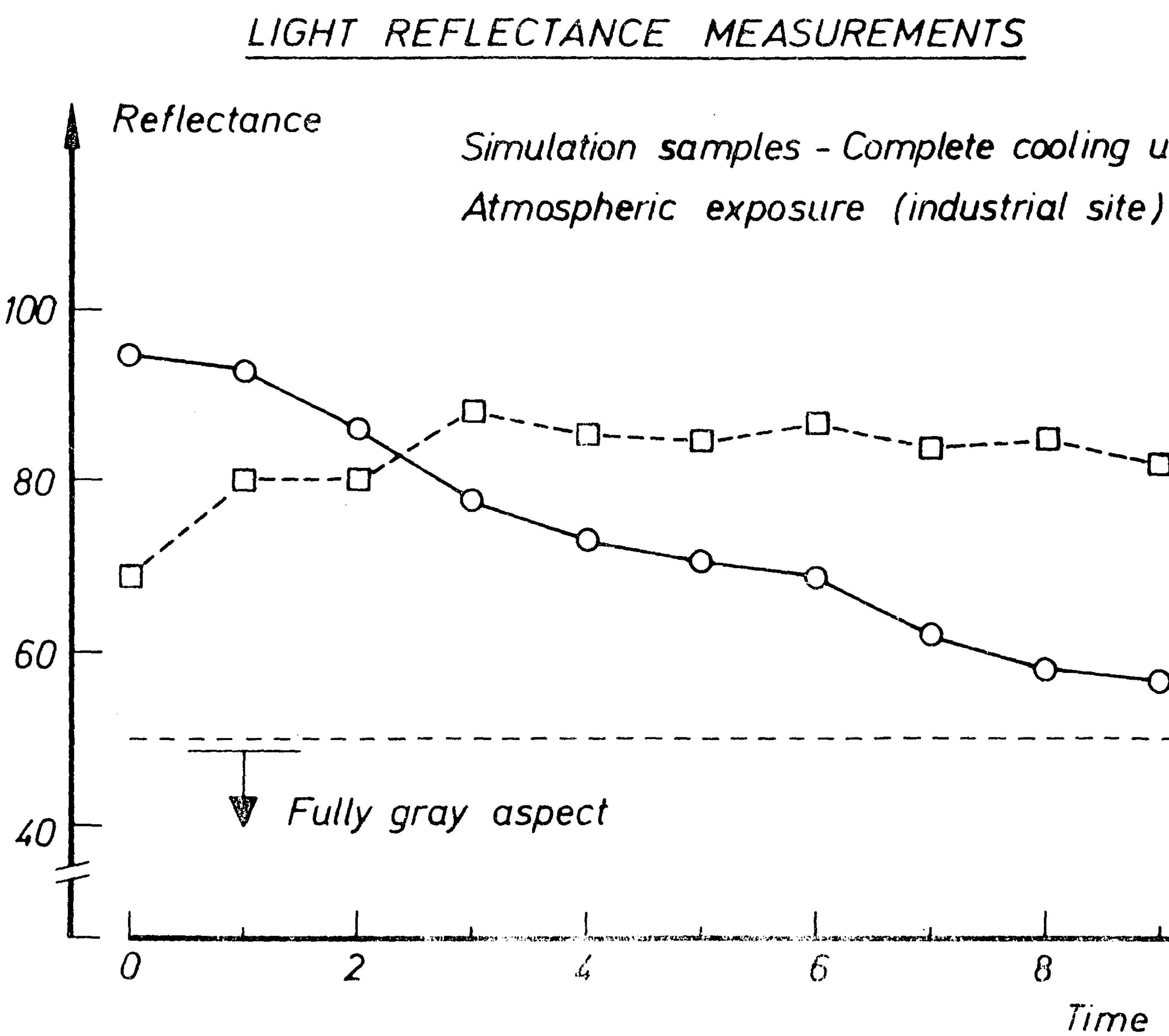
CHROMIUM PVD COATING

SUBSTRATE : GALFAN FROM SIMULATION EQUIPMENT
COOLING UNDER N_2-$5H_2$ ATMOSPHERE

Cr COATING BY SPUTTERING

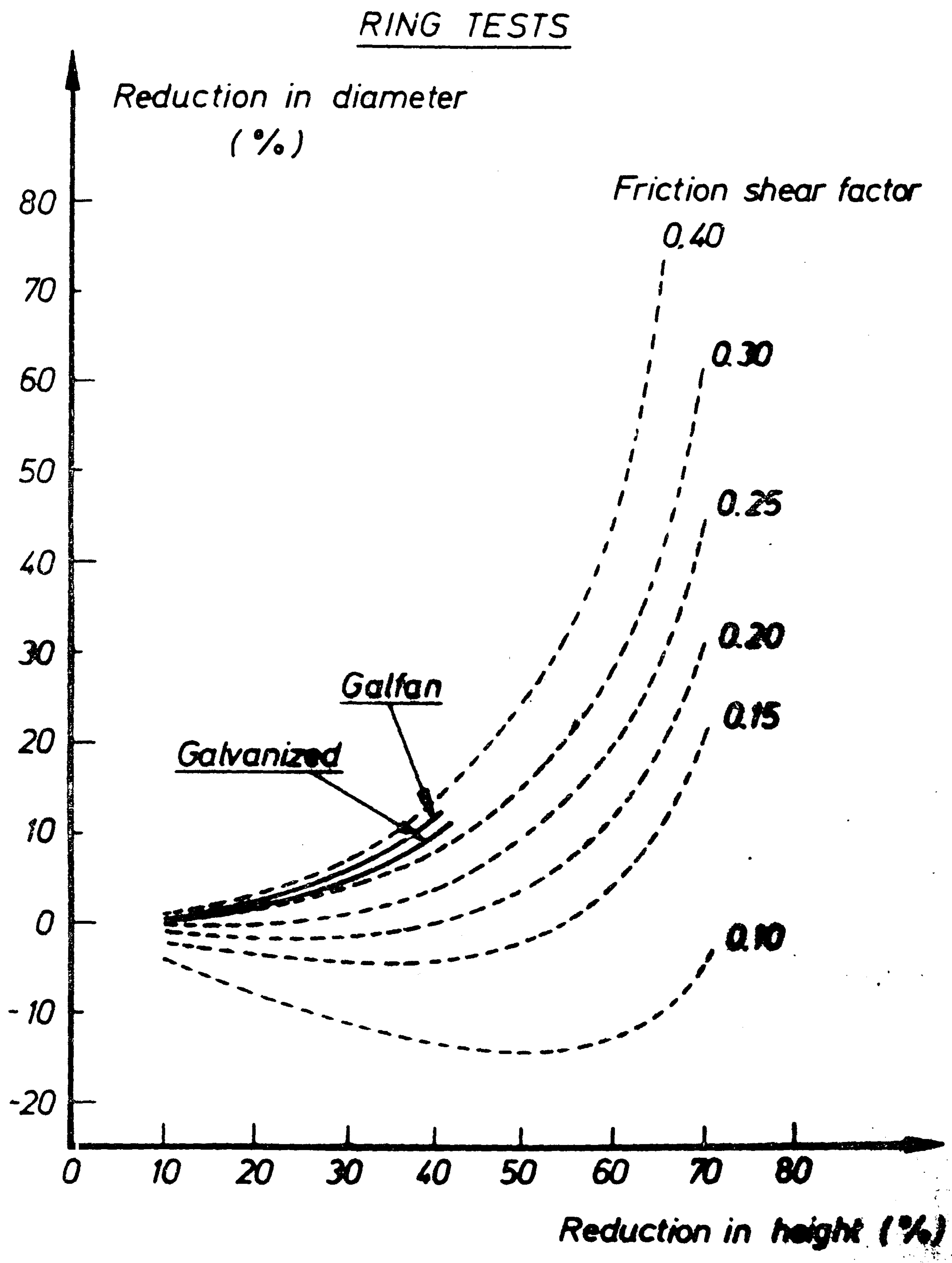
LIGHT REFLECTANCE MEASUREMENTS




LIGHT REFLECTANCE MEASUREMENTS
Reflectance
Simulation samples - Complete cooling u
Atmospheric exposure (industrial site)
100
80
60
40
Fully gray aspect
0
2
4
6
8
Time

RESIDUAL REFLECTANCE (%) AFTER ATMOSPHERIC EXPOSURE (INDUSTRIAL S

SUBSTRATE	POST-TREATMENT	EXPOSURE T	
		2 MONTHS	6 MONTHS
GALFAN HOESCH	NONE	62%	54%
	NI ELECTROLESS PLATING	73%	58%
	BRUGAL T3MG (50%)	90%	87%
SIMULATION SAMPLES	NONE	91%	73%
	CR PVD COATING ($\simeq 1\mu$)	117%	126%



RING TESTS
Reduction in diameter (%)
Friction shear factor
0.40
0.30
0.25
0.20
0.15
0.10
Galfan
Galvanized
80
70
60
50
40
30
20
10
0
-10
-20
0
10
20
30
40
50
60
70
80
Reduction in height (%)

Zinc Institute 1987 Annual Meeting, March 30, 1987, San Francisco, CA

Prospects for Zinc-Coated Sheet Steel in Germany - with a Special View of GALFAN

Guenter Reh and Bernd Meuthen
Hoesch Stahl AG, Dortmund, F.R.Germany

The German steel industry, ranking No.5 worldwide, raw-steel production, in conjunction with a drastic reduction of capacity and work force, has been focusing on steel flat products. A total of 18 captive galvanizing and coil coating lines, together with captive facilities for precoated building panels and related products, is characteristic of technical developments and intensive market approach which has resulted in a leading position in Western Europe.

Coatings include pure zinc and zinc-alloys applied by both the hot-dip and the electrolytic process, not forgetting ZINCROMETAL, the one-sided zinc-rich prepainted sheet. Between 1959 and 1963, the basic continuous coating techniques were introduced. Over the past few years, zinc-alloy coated sheet of either kind has entered the scene. A wide selection of precoated steels is now available. A detailed survey also describes an improved coating type designation.

Annual shipments of galvanized sheet have increased since the early 1980's, exceeding now two million tons. Electrogalvanized sheet achieved an important role by more than 20% production share last year. This demand spurred by the European automotive industry explains the start-up of four new high-speed electrogalvanizing lines (width, 76in. maximum, speed, 600fpm maximum) of the "third generation" in Germany.

Dipl.-Ing. G. Reh, Works Manager, Hot-Dip Galvanizing and Coil Coating
Dr. B. Meuthen, Head, R+D Surface Technology Dept.

Some major technical developments to be mentioned include:

1. A trend toward reduced zinc coating weights with hot-dip galvanizing, but generally heavier coatings with electrogalvanizing.

2. A trend toward improved surface appearance for use in exposed car-body panels, through low-lead containing hot-dip zinc coatings.

3. The increasing importance of continuously annealed sheet, interstitial-free, and micro-alloyed steels.

4. The operating of dual-purpose coating lines to achieve better flexibility.

5. The availability of large-size (83in. by 157in. maximum) hot-dip galvanized cut lengths joined by the laser welding technique to meet special demands of the automotive industry.

6. The use of heavier zinc and zinc-alloy ingots (up to 4 tons) for hot-dip coating.

Apart from the traditional end-uses of galvanized sheet steel, such as within the building and general sheet fabricating industries, the corrosion combating measures of the automotive industry have led to a fast growing demand for high-grade precoated products. Since 1976, Porsche cars have been built using the all-galvanized sheet concept. In 1985, Audi started to switch to a similar concept on all of its cars, with hot-dip galvanized sheet used for mostly unexposed panels and two-sided electrogalvanized sheet used for outer skin panels. This decision has resulted in an average zinc consumption of some 12 lbs. per vehicle.

This approach is being adopted by two other European car manufacturers. On the other hand, several well-known companies have specified electrogalvanized sheet, both one-sided and two-sided, the result totaling a portion of up to about 60% of the bodyshell. By the end of the 1980's, an average galvanized steel usage of some 350 lbs. per vehicle seems realistic in Western Europe.

GALFAN, the zinc-5%aluminum-mischmetal alloy coating developed by CRM (Centre de Recherches Métallurgiques), Liège, Belgium, under the sponsorship of ILZRO (International Lead Zinc Research Organization), New York, N.Y. has been selected for a new generation coated sheet steel in Europe for some years. GALFAN sheet is now commercially available from three European producers.

Since 1984, Hoesch Stahl has supplied some 36,000 tons, by far the largest amount in the prepainted form. At present, GALFAN is produced on the No.2 hot-dip galvanizing line (65in. wide, 430fpm maximum, monthly capacity, 26,000 tons) through campaigns about every three months. An improved coating technique has resulted in extra-smooth surfaces. An upgrading program is aimed to provide for a quick-change production of galvanized sheet, GALFAN, and also GALVALUME, as of 1988.

The German Galvanizers Association (DVV), Duesseldorf, representing most major German continuous sheet galvanizers and coil coaters, runs technical and marketing committees and task forces. A GALFAN manual entitled "Characteristic Features of GALFAN Hot-Dip Coated Sheet Steel" will soon be published. This document contains a survey of types and grades available, delivery conditions, handling and fabrication guidelines, etc. Standardized coating masses specified in grams per square meter, total both sides, are lower by 5 - 7% compared with conventional hot-dip coatings of the same thickness.

GALFAN is considered to have unique advantages over hot-dip galvanized sheet. These enhanced properties include:

1. Improved corrosion resistance without any loss of cathodic protection.
2. Excellent formability needed for tight bending and deep-drawing operations, without any loss of coating adhesion. GALFAN is much less susceptible to cracking upon forming.
3. Enhanced suitability for coil coating. Properly selected pretreatments and primers result in excellent product performance.
4. Some customers have claimed its improved chemical resistance and stamping behavior, the second resulting in reduced lubrication and higher output.

Typical applications of bare GALFAN are automotive "underhood" components, such as oil filter cans, headlight supports, housings for electric drives, and V-belt pulleys.

Prepainted GALFAN has been successfully adopted for window frame sections, dishwasher wrappings, garage doors, room partitions, waste-can lids, and pre-engineered building panels, to name just a major selection of end-uses. More time will be needed to get additional official approvals of prepainted structural thin-walled building panels.

However, GALFAN is not a material for everything. On account of its aluminum content, a general use for car-body panels made of various kinds of sheet steel seems difficult.

Nevertheless, the prospects for GALFAN look promising. There will be some continuing replacement of hot-dip galvanized sheet. Even more impressive is a gaining acceptance of prepainted GALFAN aimed to substitute porcelain-coated and otherwise postfinished cold-rolled sheet steel; i.e., GALFAN offers new customers the technical and economic advantages of the precoated sheet concept, resulting in wider applications of zinc coatings. A major upswing is expected in due time.

This message should encourage both the zinc industry and the continuous galvanizers inclusive of the steel industry involved to fight jointly for a prosperous future.

PROSPECTS FOR ZINC-COATED SHEET STEEL IN GERMANY – WITH A SPECIAL VIEW OF GALFAN

Günter Reh and Bernd Meuthen
Hoesch Stahl AG, Dortmund, F.R.G.

presented at
Zinc Institute 1987 Annual Meeting, March 30, 1987, San Francisco, CA

The West German Steel Industry (1986)

- Raw-steel production: 37.1 million M.T.
- Level of capacity used: 80 %
- Drastic reduction of capacity and work force
- Captive galvanizing and coil coating lines
- Captive facilities for building panels and related products
- Leading position in Western Europe

German Steel Companies with Captive Precoating Lines

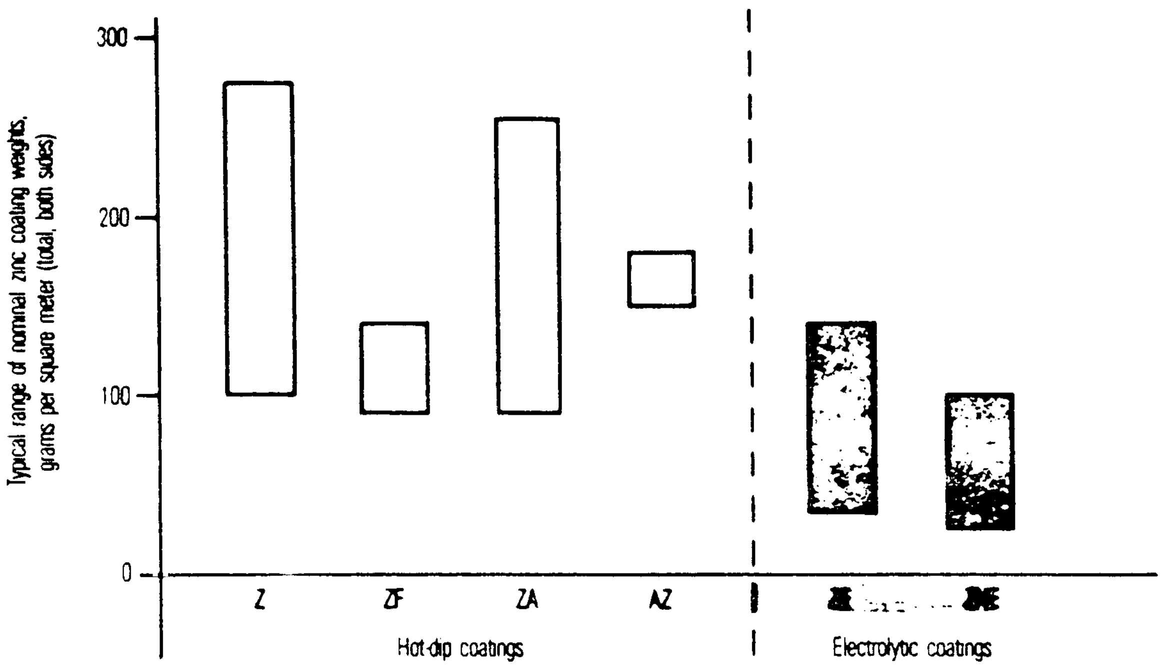
Producer	Hot-dip galvanizing				Electrogalvanizing		Coil coating	Precoated building products
	Z	ZF	ZA	AZ	ZE	ZNE		
Hoesch Stahl	●		●	○	●		●	●
Krupp Stahl					●			
Rasselstein						●		
Salmax	●		○		○		●	●
Thyssen Stahl	●	●	○		●		●	●
Total No. of lines	6				7		5	

Key: ● = commercial production ○ = trial runs or lines under construction

Survey of Continuous Zinc-Coated Sheet Steel Varieties

Coating process	Coating type	Designation	Product name
Hot-dip	zinc zinc — 11 % iron alloy zinc — 5 % aluminum — mischmetal alloy 55 % aluminum — 43.4 % zinc — silicon alloy	Z ZF ZA AZ	— galvannealed GALFAN GALVALUME
Electrolytic	zinc zinc — 12 % nickel alloy zinc — iron alloys	ZE ZNE ZFE	— — —
Organic	zinc — rich paint	—	ZINCROMETAL

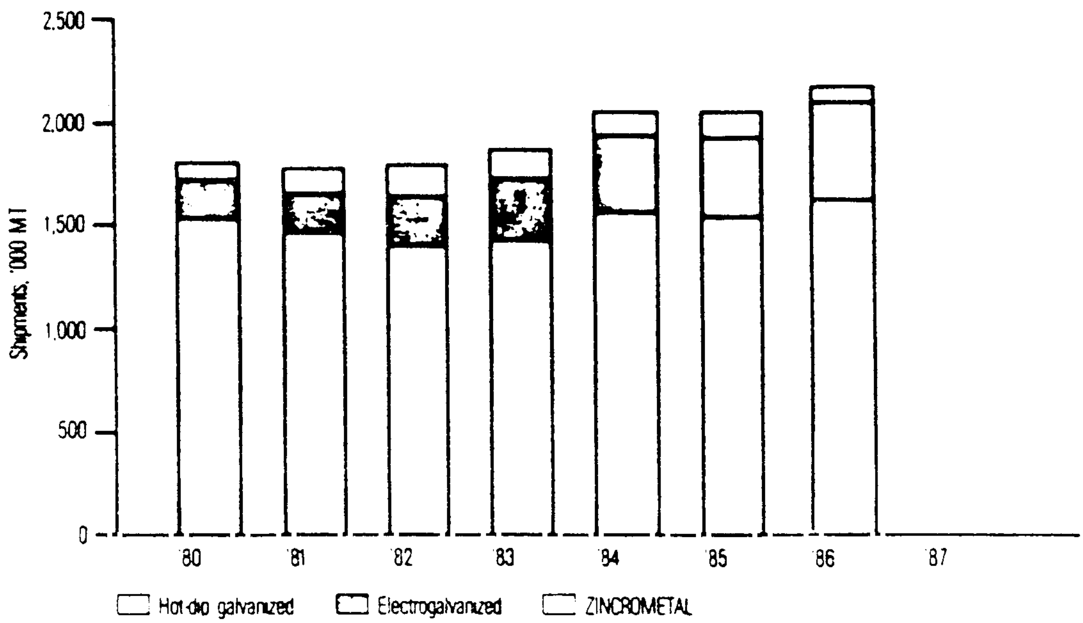
Zinc Coating Weights



Start-up of Commercial Production of Precoated Sheet Steel in W. Germany

Phase 1: Basic processes	Intermediate phase	Phase 3: Alloy coating
1959, Hot-dip galvanizing		**1984,** GALFAN
1960, Coil coating	**1974,** ZINCROMETAL	**1985,** Electrogalvanizing, Zn-Ni type Galvannealing
1963, Electrogalvanizing		**1988,** GALVALUME

Total Shipments of Galvanized Sheet and ZINCROMETAL from German Steel Producers



(Sources: Statistisches Bundesamt, Deutscher Verzinkerei Verband)

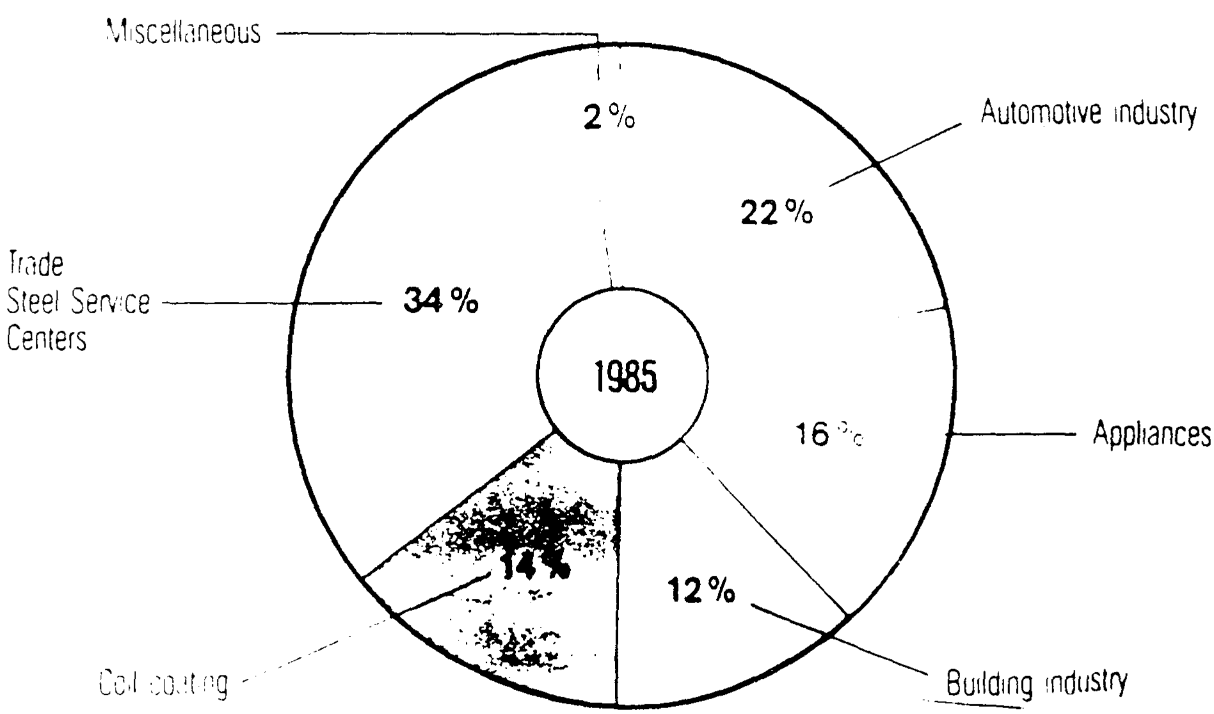
New Electrogalvanizing Lines in W. Germany

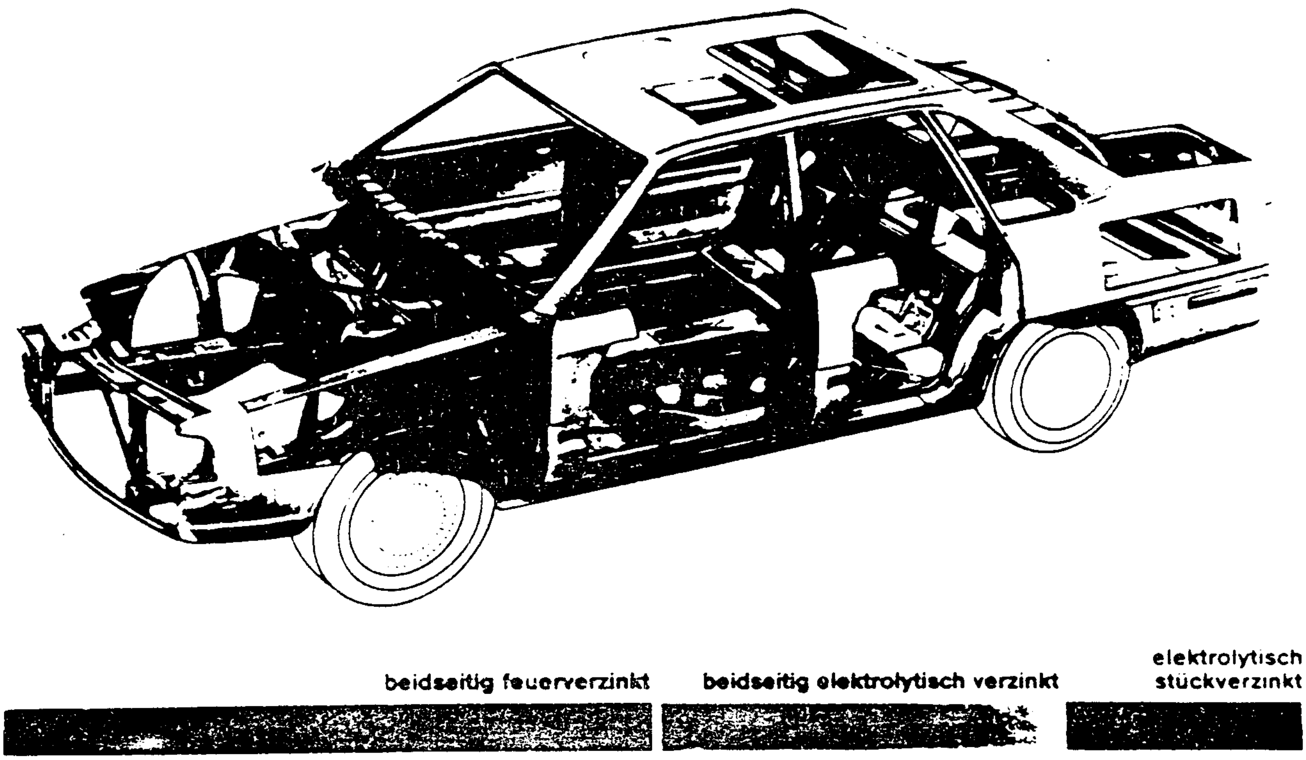
● Companies:	No. 3 Hoesch Stahl No. 2 Krupp Stahl No. 1 Salmax No. 3 Thyssen Stahl
● Start-up:	1986/87
● Width:	76 in. (1,950 mm) maximum
● Speed:	600 fpm (180 m/min) maximum
● Plating technique:	horizontal vs. vertical cells, soluble vs. insoluble anodes, high current densities
● Coating:	pure zinc, one and two-sided

Major Technical Developments and Trends

- Reduced zinc coating weights with hot-dip galvanizing, but generally heavier coatings with electrogalvanizing
- Improved surface appearance with hot-dip galvanizing by increasing use of low-lead baths
- Increasing importance of (a) continuously annealed sheet,
  (b) interstitial-free, and
  (c) microalloyed steel grades
- Operating of dual-purpose coating lines
- Availability of large-size hot-dip galvanized cut lengths joined by the laser welding technique
- Use of heavier zinc and zinc-alloy ingots

Breakdown of Major Domestic End-Uses of Galvanized Sheet Steel from German Producers





The all-galvanized sheet concept used by AUDI

GALFAN-Coated Sheet Steel in Europe

● Background:	Research initiated at CRM, Liège, Belgium and sponsored by ILZRO, New York:	1979
	First CRM trial runs:	1980
	First Ziegler industrial runs:	1981
● Licensees:	include 13 major steel companies (galvanizers)	
● Commercial suppliers:	Ziegler and FF Maubeuge, France Hoesch Stahl, W. Germany	
● Trademark:	GALFAN	

GALFAN-Coated Sheet Steel at Hoesch Stahl

● Licensed:	1982
● First trial runs:	1983
● Commercial production:	since 1984
● Production campaigns:	about 4,000 to 5,000 M.T. each run, four times a year
● Cumulative shipments:	36,000 tons (as of March '87)
● Breakdown of end-uses:	bare: 15 % prepainted: 85 %

Multipurpose Hot-Dip Galvanizing Line

No. 2 Hoesch Stahl, Kreuztal-Eichen plant

● Started:	1966
● Width:	65 in. (1,650 mm) maximum
● Speed:	430 fpm (130 m/min) maximum
● Capacity:	26,000 tons per month (36 tons an hour)

● Equipped with Heurtey minimized spangle unit

To be rebuilt in 1988

● To include two interchangeable ceramic pots plus two stand-by pots

● Products: Hot-dip galvanized
GALFAN
GALVALUME

"Characteristic Features of GALFAN Hot-Dip Coated Sheet Steel"
Manual, published 1987 by German Galvanizers Association (DVV), Düsseldorf

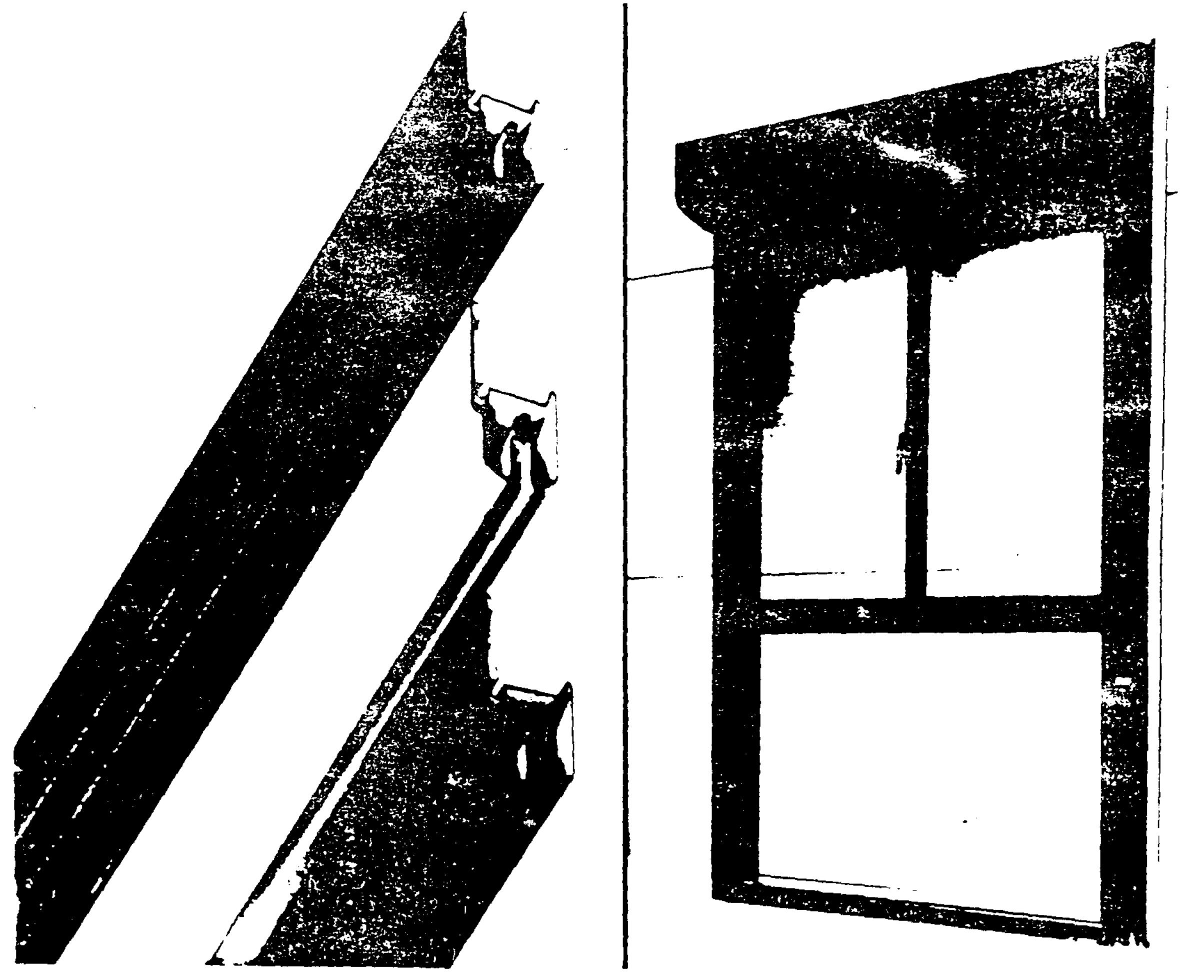
In accordance with other DVV manuals and DIN standards on hot-dip galvanized sheet

- Availability
- Forming grades
- Designation and nominal coating weights
- Surface finishes
- Surface appearance
- Post-treatment, testing, handling/fabrication, ordering information, and packaging

Advantages of GALFAN-Coated Sheet

- Improved corrosion resistance without loss of cathodic protection
- Excellent formability needed for tight bending and deep-drawing without loss of coating adhesion
- Enhanced suitability for coil coating with excellent product performance
- Improved chemical resistance and stamping behavior

GALFAN used for severely formed "underhood" components



WEIRTON STEEL CORPORATION
PRESENTATION FOR TENTH GALF
LICENSEES MEETING
MAY 20, 1987

CHEMICAL TREATMENT PERFORMANCE

KESTERNICH TEST PERFORMANCE (Unpai

SPOT WELDING

PAINTABILITY

CHEMICAL TREATMENT PERFORMANCE OF GALFA
RESISTANCE TO WHITE RUSTING
Procedure

- SAMPLE COMMERCIAL PRODUCTION OF CHEM TREATED GALFAN
  - DIRECTLY OFF LINE
  - AFTER SUBSEQUENT SKIN ROLLING
- MEASURE CHEM TREAT LEVEL
- MEASURE RESISTANCE TO WHITE RUSTING USING STACK TEST

CHEMICAL TREATMENT SYSTEM
OKEMCOAT F1

- PATENTED PRODUCT PRODUCED BY OAKITE PRO
- CHROMATE BASED CONVERSION COATING
- APPLICATION BY SPRAY PLUS SQUEEGEE ROLL
- SAME SYSTEM USED FOR GALFAN AND HOT DIP GALVANIZE
- NORMAL CHROME LEVEL ON TREATED MATERIAL IS 3 TO 6 MICRO-GRAMS/SQ. INCH

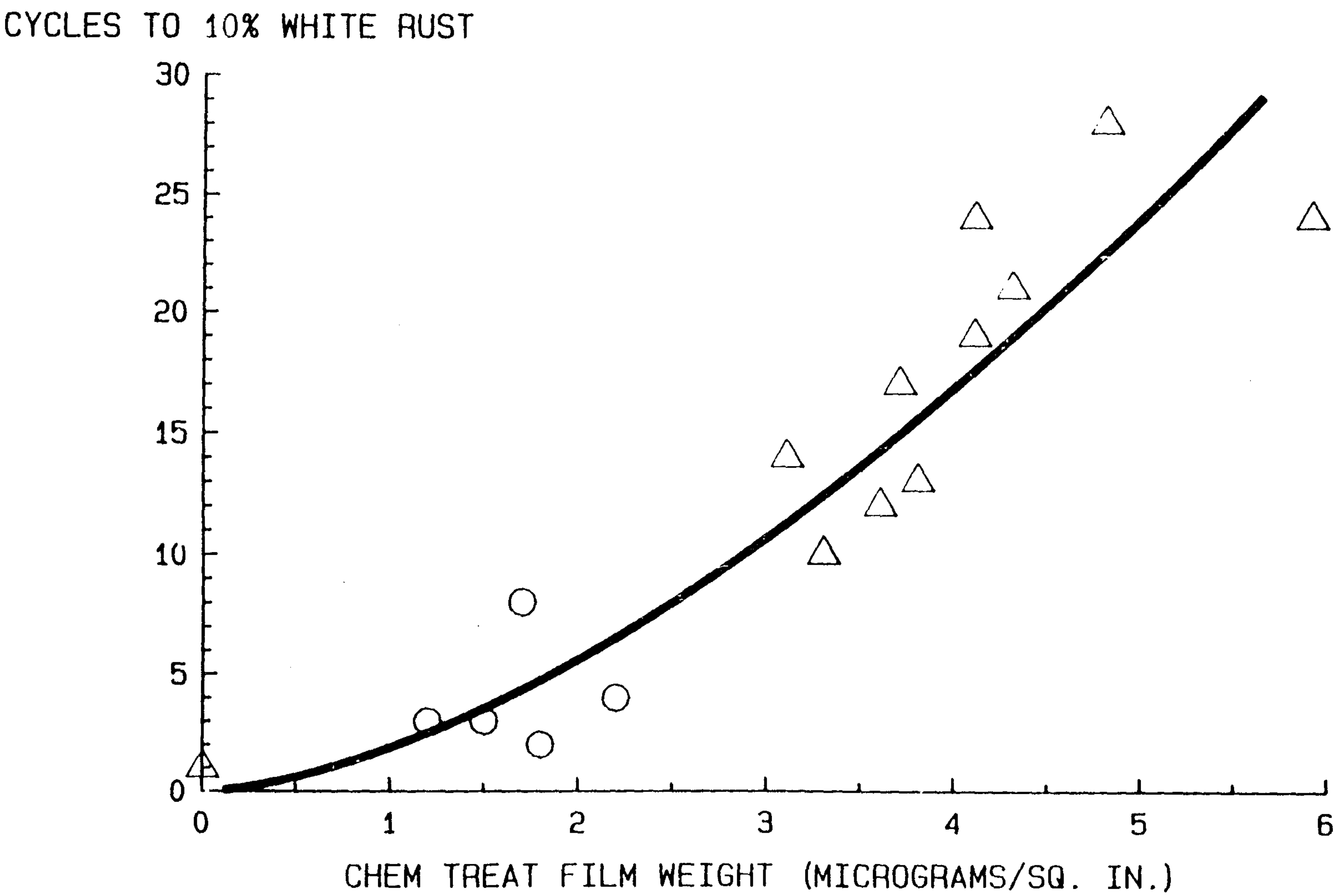
STACK TEST PROCEDURE

- CUT AT LEAST THREE PANELS 1 FT BY 1 FT OF EACH MATERIAL
- STACK PANELS AFTER SPRAYING WATER ON EA
- APPLY WEIGHT AND LET STAND AT ROOM TEMPERATURE FOR 5 DAYS (ONE CYCLE)
- EVALUATE AND RE-WET AFTER EACH CYCLE
- TERMINATE TEST WHEN ANY PANEL FROM THE HAS AT LEAST 10% WHITE RUST
- PRODUCTION MATERIALS MUST SURVIVE 2 CYC TO PASS THE TEST

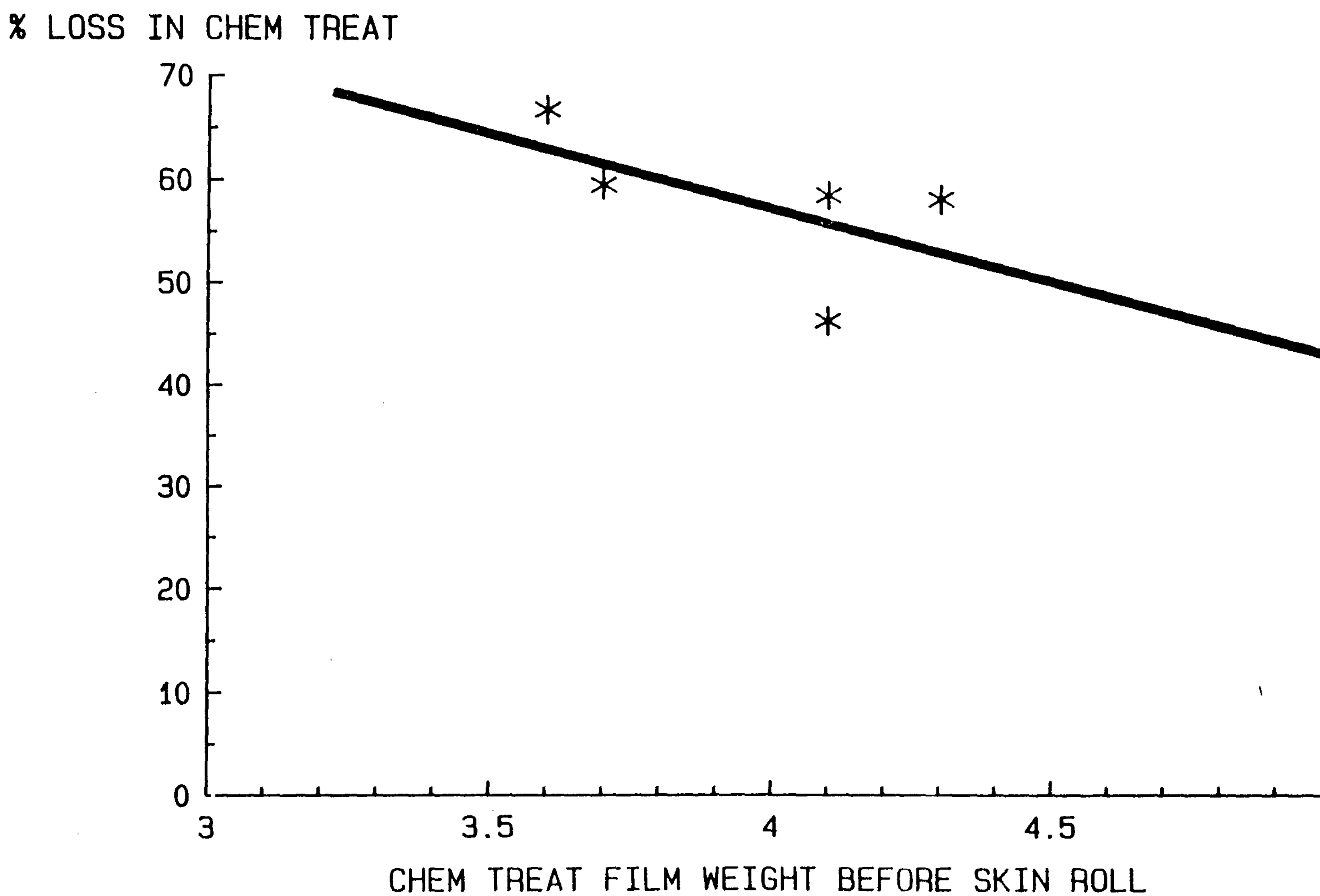
RESULTS

- CHEM TREAT LEVELS OFF LINE VARIED FROM
5.9 MICRO-GRAMS/SQ. INCH (SIMILAR TO HD
- SKIN ROLLING REDUCED CHEM TREAT LEVEL BY AS MUCH AS 67%
- STACK TEST CYCLES TO 10% WHITE RUST WER
PROPORTIONAL TO CHEM TREAT LEVEL
- RESISTANCE TO WHITE RUSTING EXCEEDED MI
REQUIREMENTS WHEN CHEM TREAT LEVELS WER
IN NORMAL RANGE

STACK TEST PERFORMANCE OF GALFAN
EFFECT OF CHEMICAL TREATMENT LEVEL
EFFECT OF POST-GALVANIZE PROCESSING



% LOSS OF CHEMICAL TREATMENT ON GALFAN AS A RESULT OF SKIN ROLLING

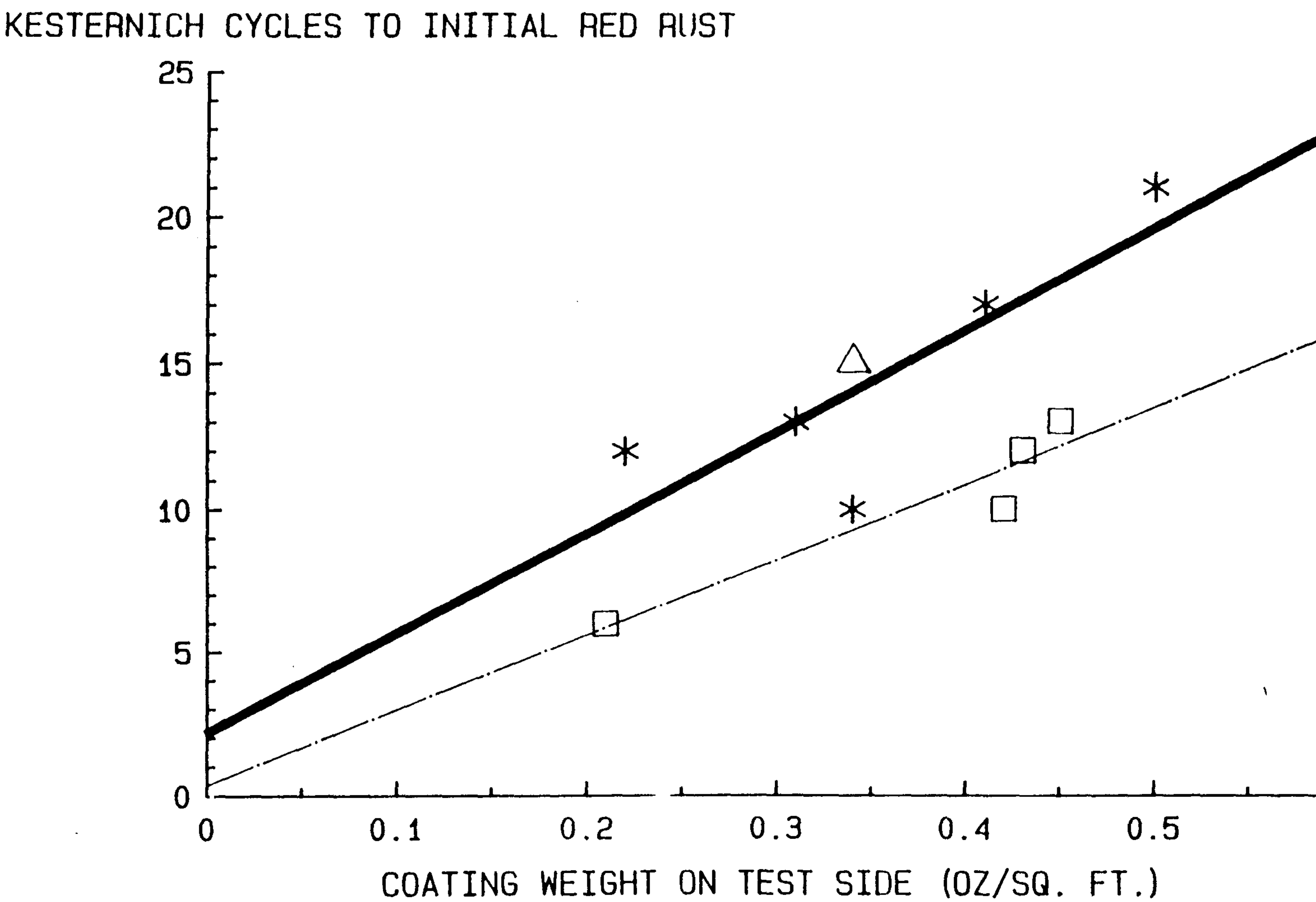


CHEMICAL TREATMENT OKEMCOAT F-1
FILM WEIGHT IN MICROGRAMS/SQ. IN.

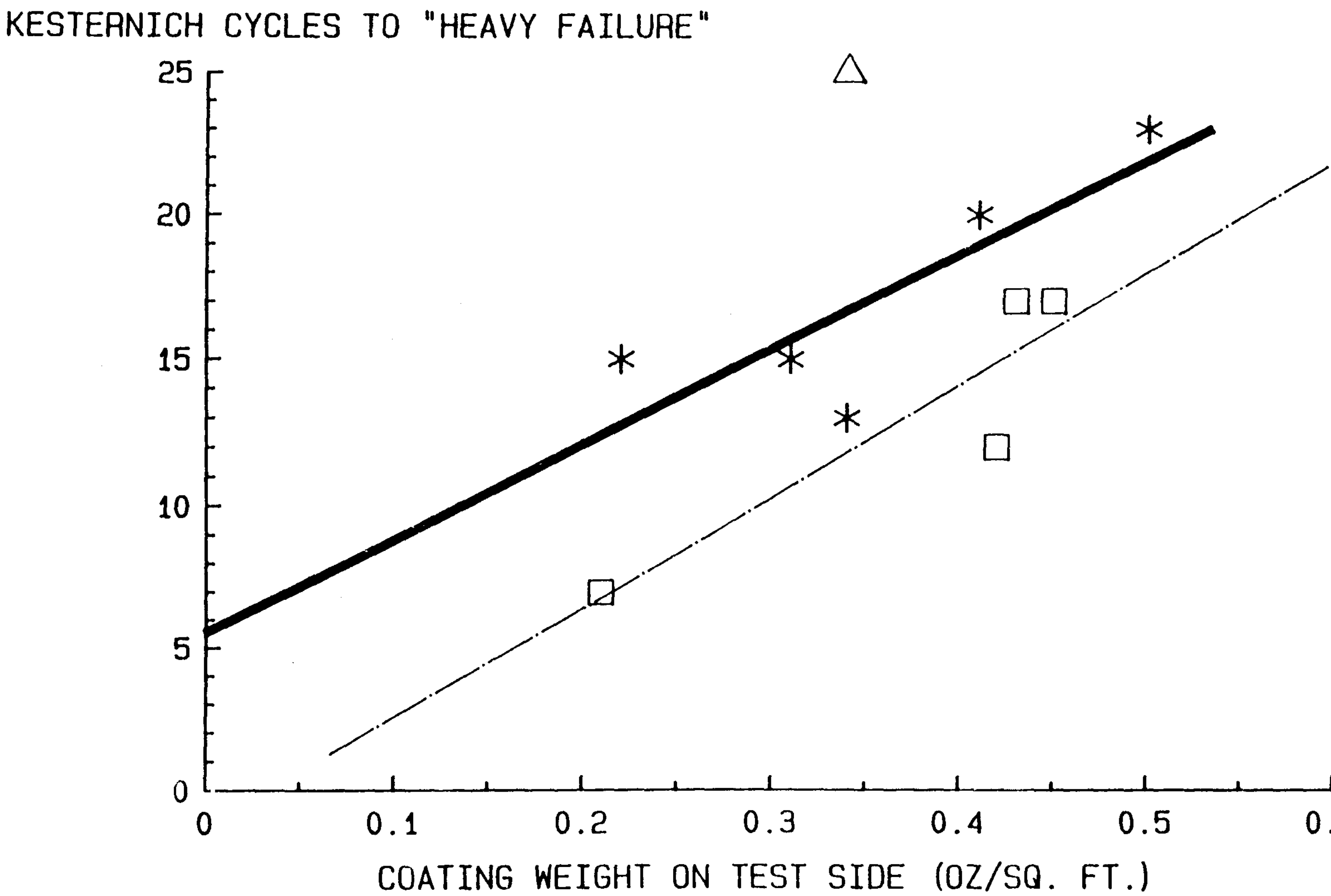
KESTERNICH TESTING OF UNPAINTED GAL
(DIN 50018; 2.0 LITERS)

- COMPARED GALFAN, HOT DIP GALVANIZE AND GALVALUME
- SAMPLES RATED BY:
  - CYCLES TO INITIAL RED RUST
  - CYCLES TO "HEAVY FAILURE"

KESTERNICH TEST RESULTS ON
BARE GALFAN, GALVANIZE AND GALVALUME--
KESTERNICH CYCLES TO INITIAL RED RUST



KESTERNICH TEST RESULTS ON
BARE GALFAN, GALVANIZE AND GALVALUME--
KESTERNICH CYCLES TO "HEAVY FAILURE"



E-COAT SYSTEMS

- GALFAN IS CURRENTLY BEING EVALUATED W
  STANDARD E-COAT SYSTEMS.

PRIMERS

VARIOUS CONVENTIONAL PRIMERS APPLIED OV
PROPERLY PRETREATED GALFAN HAVE BEEN EV

- EPOXY
- URETHANE
- WATER-BASED

THE BEST PRIMERS IN TERMS OF OVERALL PE
WERE THE EPOXY AND URETHANES.

NEW EXPERIMENTAL PRIMERS, WHICH INCLUDE
FILM TECHNOLOGY, INCREASED FLEXIBILITY,
INCREASED CORROSION PROTECTION, ALSO RE
EXCELLENT PERFORMANCE OVER THE PROPERLY
PRETREATED GALFAN SUBSTRATE.

TOP COATS

VARIOUS CONVENTIONAL TOP COATS APPLIED
PROPERLY PRIMED GALFAN HAVE BEEN EVALUA

- POLYESTER
- SILICON POLYESTER
- CERAMIC PIGMENTED SILICON POLYESTER
- FLUOROCARBON (MINIMUM 70% KYNAR 500 - P
- PLASTISOL
- CERAMIC PIGMENTED PLASTISOL
- URETHANE
- WATER-BASED

CONSISTENTLY, THE BEST PRETREATMENTS (A
LABORATORIES) IN TERMS OF OVERALL PAINT
PERFORMANCE (ADHESION, SALT SPRAY, ETC.
THE FOLLOWING:

- PARKER B-1421 - ZINC PHOSPHATE
- AM CHEM G-46-S - ZINC PHOSPHATE
- J.M.E. 2-1-200 - CHROME OXIDE

THE BEST PRETREATMENT WAS THE PARKER B-
ZINC PHOSPHATE - HIGH NICKEL, FINE GRAI
TERMS OF OVERALL PERFORMANCE.

PRETREATMENTS

GALFAN IS AN EXCELLENT BASE FOR CONVENT
ADVANCED TECHNOLOGY PAINT PRETREATMENTS
PRETREATMENTS CURRENTLY USED ON CONVENT
GALVANIZED ARE ALSO COMPATIBLE WITH GAL

THE FOLLOWING PRETREATMENTS (APPLIED IN
LABORATORY OF PRETREATMENT COMPANY AND/
COMPANY) HAVE BEEN EVALUATED:

PAINTABILITY OF GALFAN

- GALFAN, WHEN PROPERLY PRETREATED, PR
EXCELLENT BASE FOR POST-PAINT AND PR
SYSTEMS.

- THE EXCELLENT FORMABILITY OF THE GAL
COATING, IN COMBINATION WITH A FLEXI
SYSTEM, PROVIDES AN ADDED OPPORTUNIT
PREVIOUSLY PROHIBITIVE PRE-PAINTED A

1,000 HOURS & 240 HOURS
CLEVELAND CONDENSING HUMIDITY
(140 DEGREES F. Q.C.T.)

- ALL OF THE PAINT SYSTEMS, WITH THE EX
THE WATER-BASED PRIMERS, REVEALED GOO
WITH NO BLISTERING BEING REVEALED ON
OF THE PANELS.

- PANEL BENDS AND 80 INCH-POUND IMPACTS
NO CORROSION PRODUCTS, AND ONLY A FEW
MICRO-BLISTERS ON SOME OF THE BENDS.

- FACE OR FIELD
  - WITH MANY OF THE PAINT SYSTEMS TES
    FACE OR FIELD REVEALED NO BLISTERS
- 0T-2T BENDS & 80 INCH-POUND DIRECT & RE
  IMPACT TESTS
  - WITH THE PROPER PAINT SYSTEM (MORE
    PRIMER AND/OR TOP COAT FORMULATION
    BLISTERING OR CORROSION PRODUCTS W
    ENCOUNTERED WITH THE GALFAN.
  - WITH COMPARABLE PAINT SYSTEMS, THE
    REVEALED LESS CORROSION PRODUCTS O
    VERSUS THE 55% AL, 43.5% ZN, 1.5%
    AND CONVENTIONAL GALVANIZED.

1,000 HOURS SALT SPRAY (ASTM B117)

SALT SPRAY TESTING OF THE VARIOUS PAINT
OVER GALFAN REVEALED THE FOLLOWING:

- EDGE CREEP
  - WITH EQUIVALENT PAINT SYSTEMS, GAL
    REVEALED EXCELLENT RESISTANCE TO E
    SIMILAR TO, AND IN MANY CASES, BET
    CONVENTIONAL GALVANIZED, AND BETTE
    55% AL, 43.5% ZN, 1.5% SI PRODUCT.
- SCRIBE
  - GALFAN REVEALED LESS SCRIBE CREEP
    BLISTERING AROUND THE SCRIBE THAN
    43.5% ZN, 1.5% SI PRODUCT, AND IN
    EQUIVALENT OR BETTER THAN CONVENTI
    GALVANIZED.

KESTERNICH (2 LITER SO2) - D.I.N. 50018

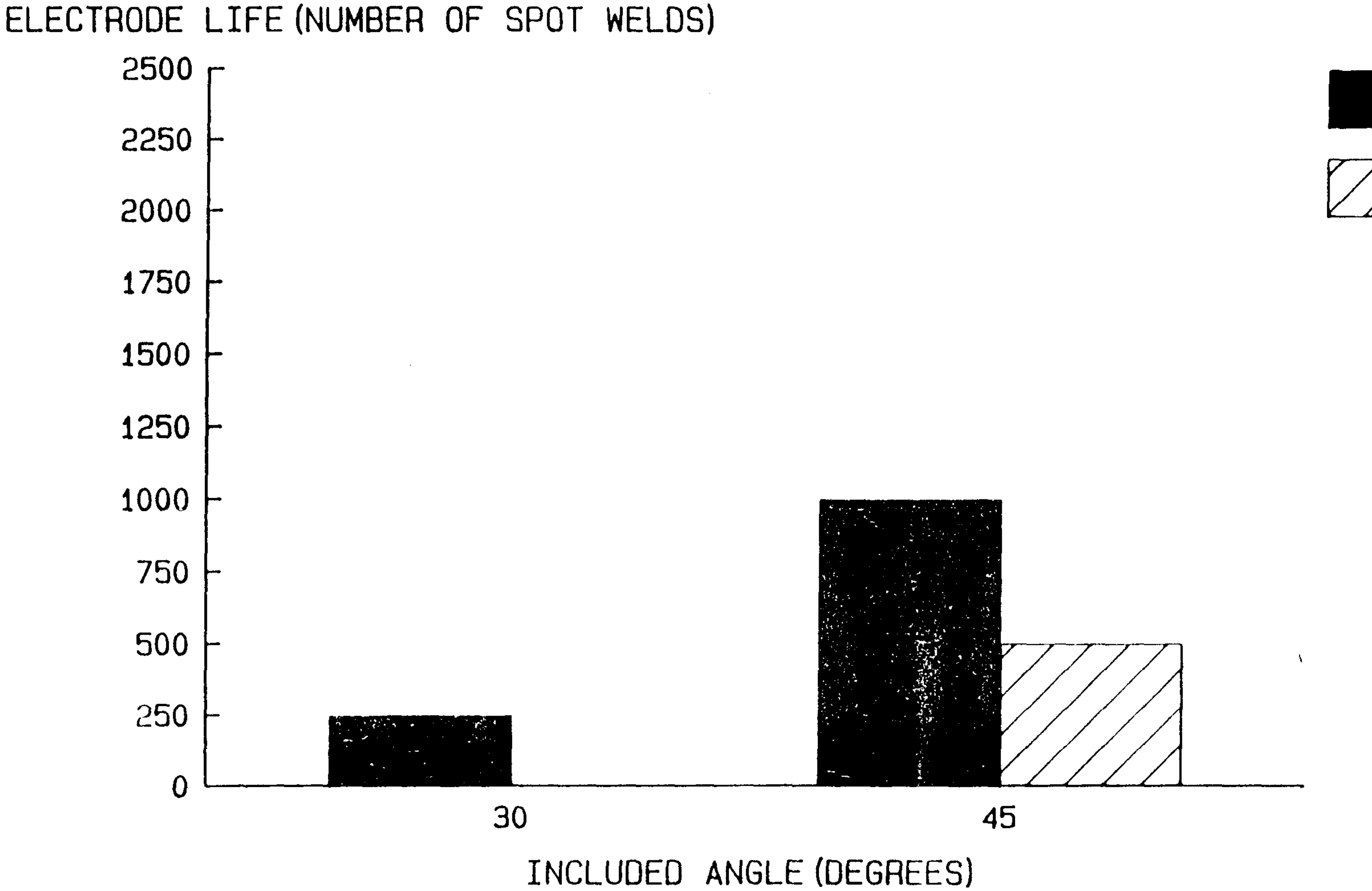
- CONVENTIONAL THIN FILM PAINT SYSTEMS W
CYCLES WITHOUT ANY BLISTERS, AND 30 CY
7-8 FINE BLISTERS. THE CUT EDGE CORRO
RANGED FROM 1 MM. TO 2 MM. AFTER 30 CY

- THE THICK FILM PRIMER (.8 MIL.) PAINT
WENT 31 CYCLES WITHOUT ANY BLISTERS.
EDGE CORROSION WAS 2 MM. AFTER 31 CYCL

POST-PAINTING

- POST-PAINT SYSTEMS CURRENTLY IN USE O CONVENTIONAL GALVANIZED CAN ALSO BE U GALFAN.
- THIS WOULD INCLUDE SUCH PAINT SYSTEMS ACRYLICS, ALKYDS, POLYESTERS, ETC.

EFFECT OF GLID-COP ELECTRODE INCLUDED ANGL
ON ELECTRODE LIFE
0.032 INCH THICK, GF30 (NOT STEAM BLOWN) MATER



GF2
12 CYCLE WELD TIME, 530 LB. WELD FORCE
0.25 INCH ELECTRODE TIP DIAMETER

ADJUSTMENTS MADE TO THE WELD SCHED

LISTED IN

FORD MOTOR SPECIFICATION BA13-

DISPERSION-STRENGTHENED (GLID-COP) ELEC

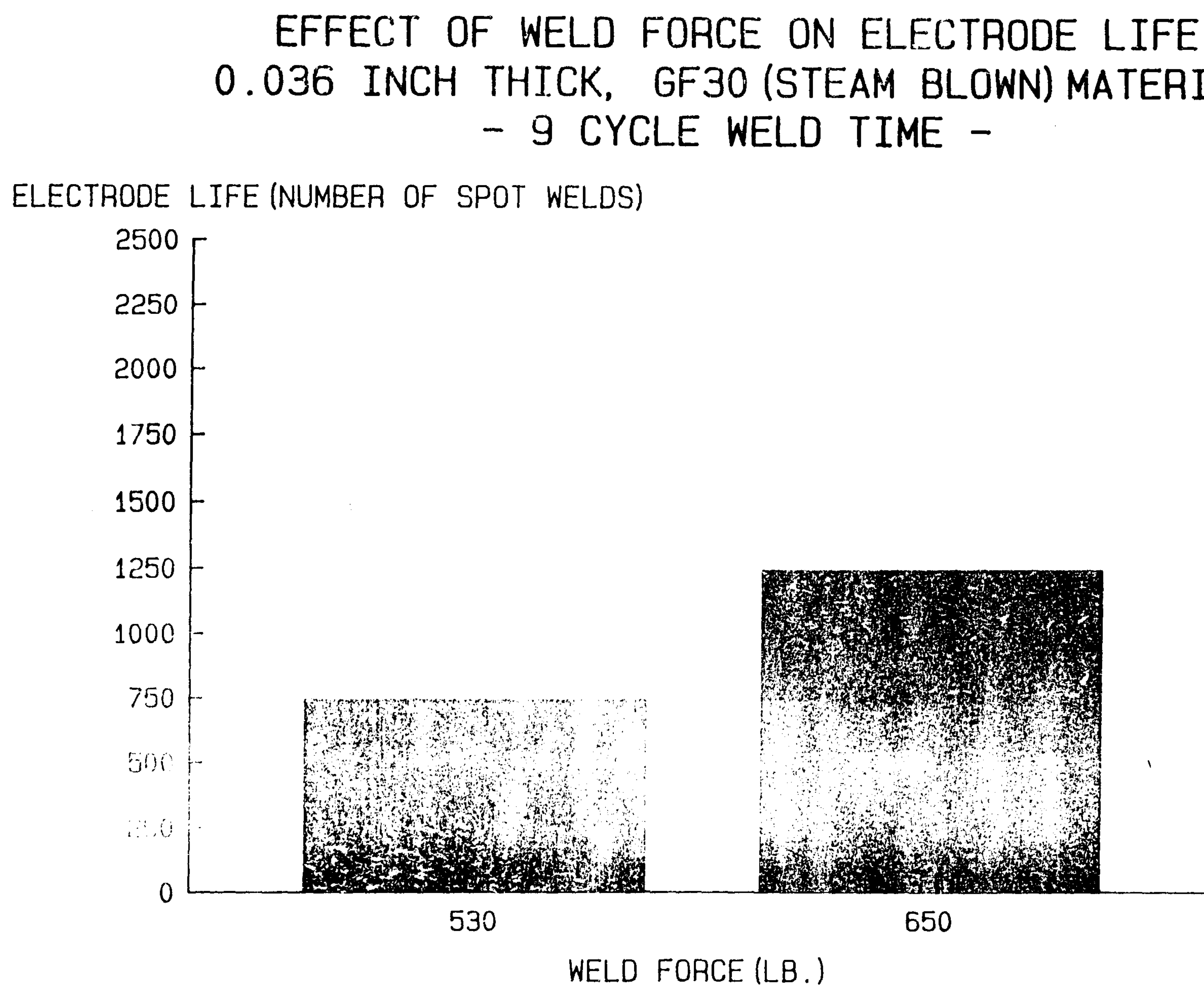
CHANGES IN THE INCLUDED ANGLE OF THE EL

CHANGES IN THE ELECTRODE TIP DIAMET

INCREASES AND DECREASES IN THE WELD

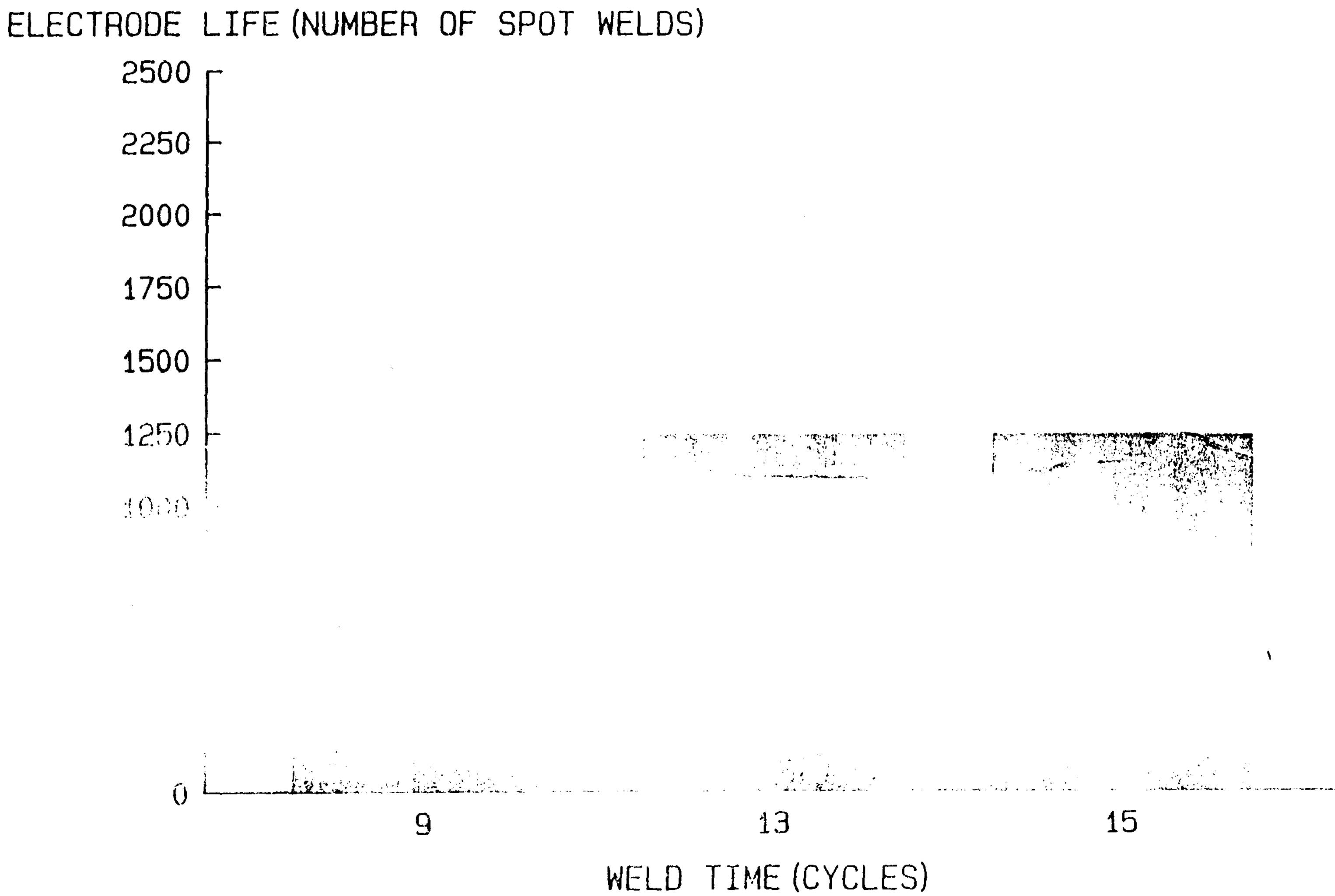
INCREASES AND DECREASES IN THE WELD

THE ADDITION OF UPSLOPE TO THE WELD SC



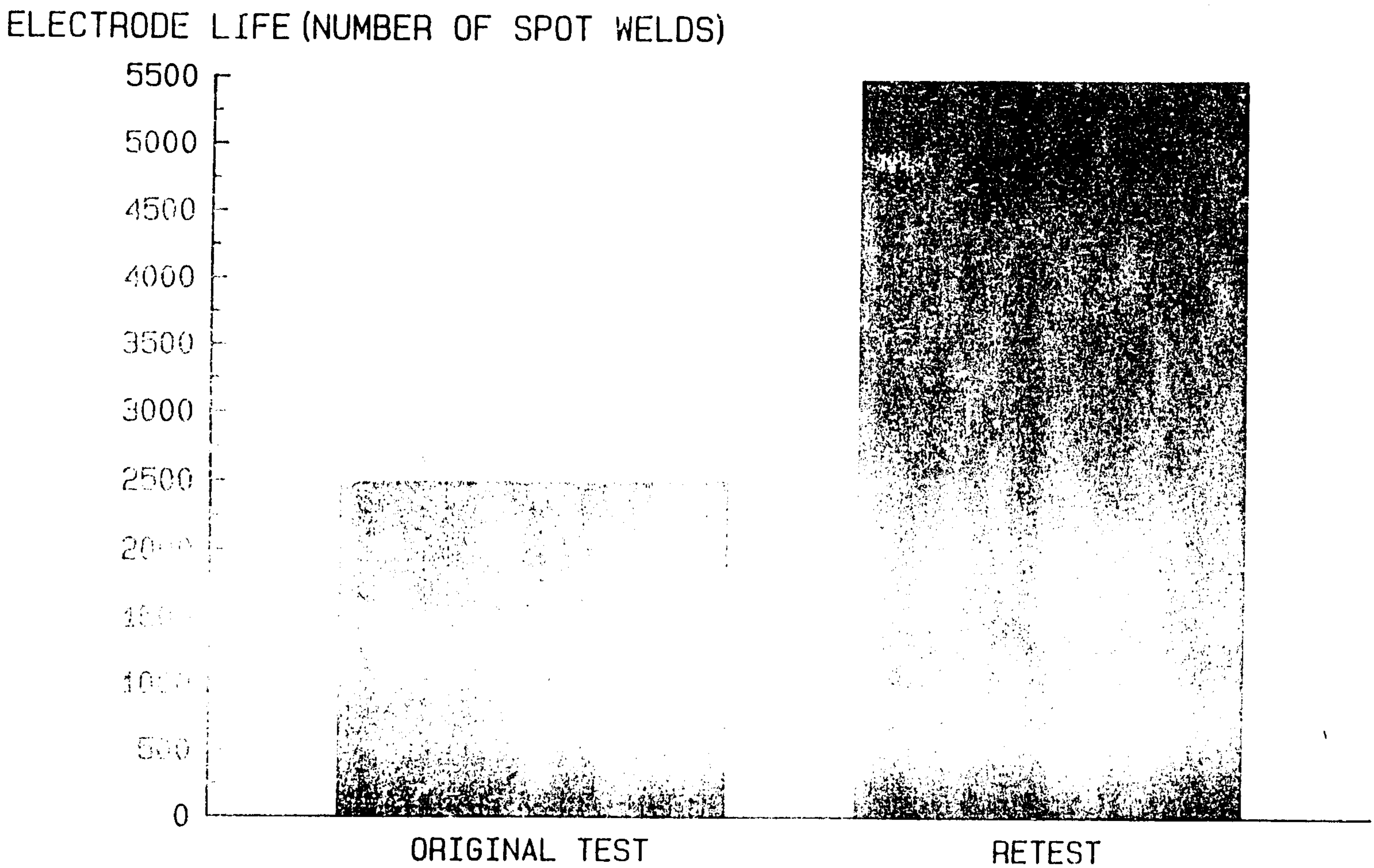
GF8
0.25 INCH ELECTRODE TIP DIAMETER (RWMA CLASS II)

EFFECT OF WELD TIME ON ELECTRODE LIFE
0.036 INCH THICK, GF30 (STEAM BLOWN) MATERI
- 530 LB. WELD FORCE -



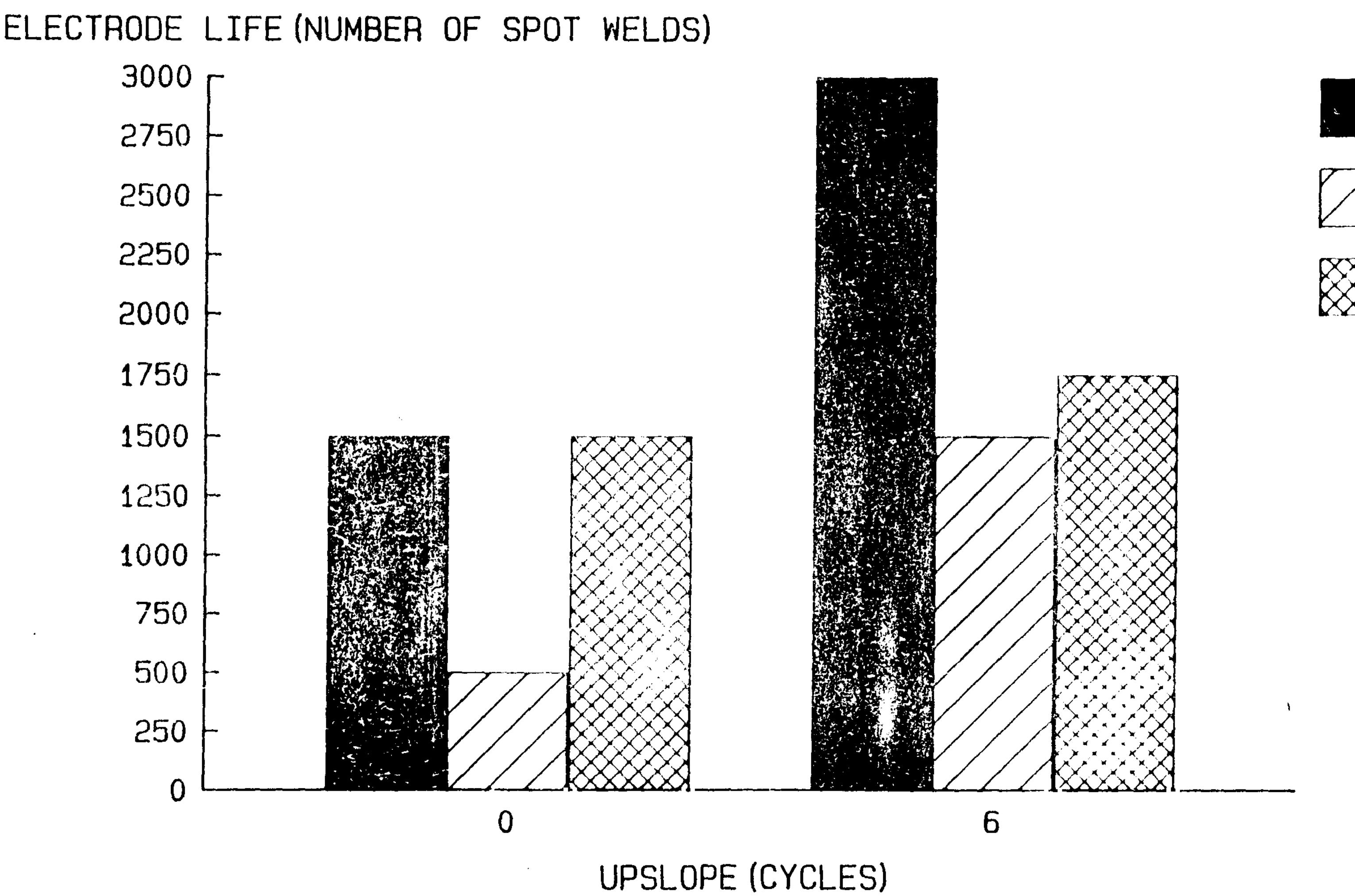
GF10
0.25 INCH ELECTRODE TIP DIAMETER (RWMA CLASS II)

ELECTRODE LIFE FOR
0.032 INCH THICK, GF45 (NOT STEAM BLOWN) MATER
- 9 CYCLE UPSLOPE -



GF12
12 CYCLE WELD TIME, 530 LB. WELD FORCE
0.25 INCH ELECTRODE TIP DIAMETER (RWMA CLASS II)

EFFECT OF UPSLOPE ON ELECTRODE LIFE
0.032 INCH THICK, GF30 (NOT STEAM BLOWN) MATER



GF6
12 CYCLE WELD TIME, 530 LB. WELD FORCE
0.25 INCH ELECTRODE TIP DIAMETER (RWMA CLASS II)

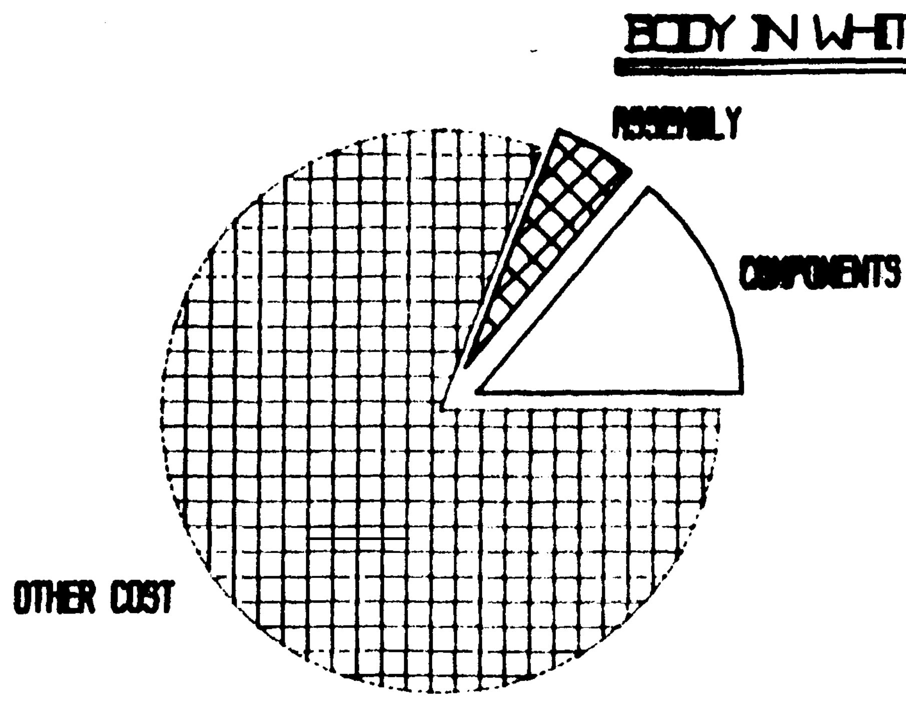
2 D A

UNIQUE PROPERTIES

GALVANISED	GALFAN	GALVALUME
GALVANIC PROTECTION	COATING DUCTILITY	CORROSION RESISTANCE
TRACK RECORD IN MARKET	TWICE AS CORROSION RESISTANT AS GALVANISED	3 TO 4 TIMES CORROSION RESISTANCE OF GALV.
		TRACK RECORD IN METAL BUILDING

Austin Matthews - BSC

THE BODY IN WHITE IS AN IMPORTANT
PART OF TOTAL MANUFACTURING COST



EQUATING UNIQUE PROPERTIES WITH MARKET NEEDS

	PRODUCTS	COMPETITION
AUTOMOTIVE	GALFAN AND GALVANISED	PLASTIC
DOMESTIC APPL.	GALFAN AND GALVANISED	PLASTIC
CONSTRUCTION	GALVALUME AND GALFAN GALV./OCS	LAMINATES. FIBRE REINF. PLASTICS.

The Zinquench Process

Aging, forming and strength characteristics.

Experiences of the production trials.

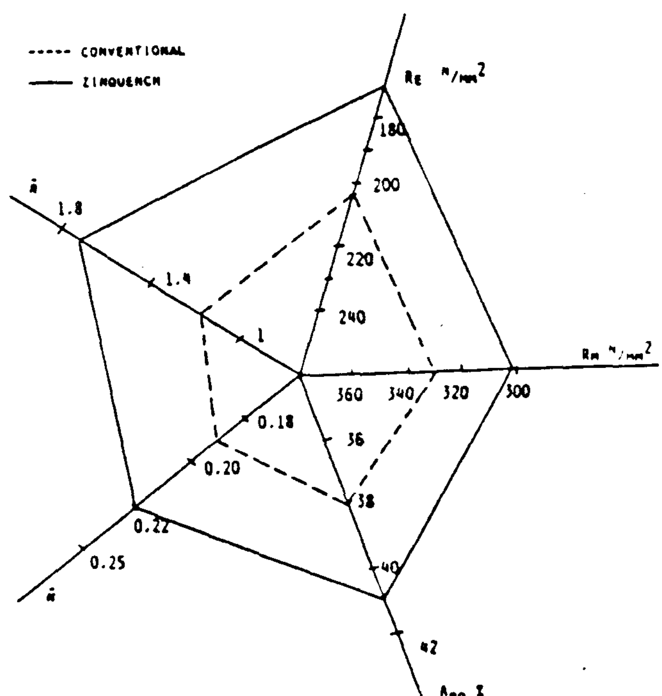
1. Steel specification

A	ULC (ultra low carbon steel) by the vacuum degassing; carbon content 0,01 % or less
	SULC (stabilized ultra low carbon steel)
B	ELC (extra low carbon steel) by the bottom blowing converter; carbon content 0,025-0,01 %
C	LC (low carbon steel) by the LD-process; carbon content 0,03 % or more

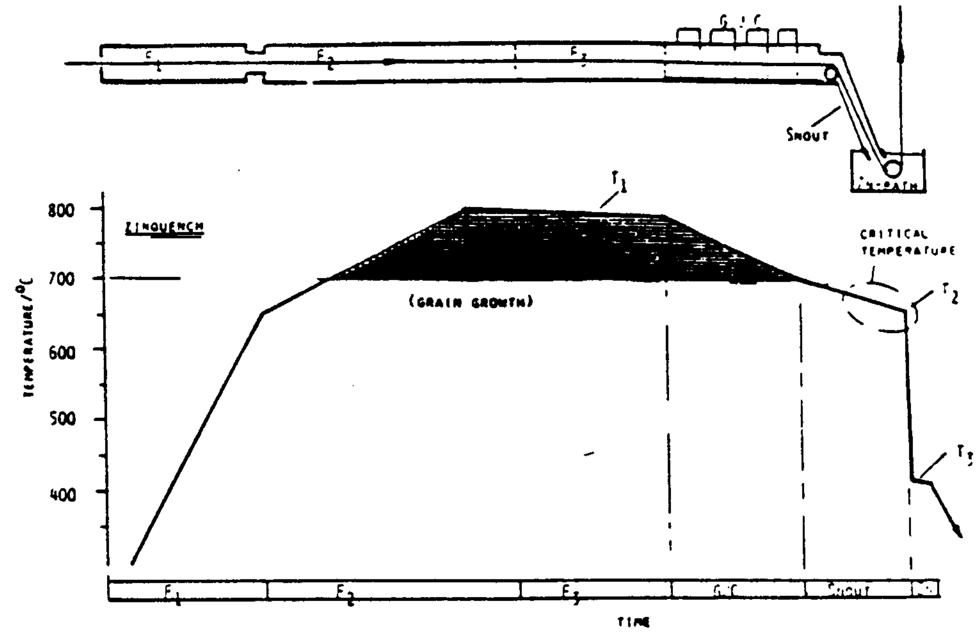
2. The mechanical properties of ELC-steel produced by the conventional process and by the ZINQUENCH

(The results are from the first ZINQUENCH-production trial and from the normal production with the conventional method.)

The coils have been post-annealed in the batch furnace.



PS 10.2.87



The critical temperature: 720 - 650 °C

- decreasing γ-phase to MINIMUM
- increasing solute carbon content in ferrite

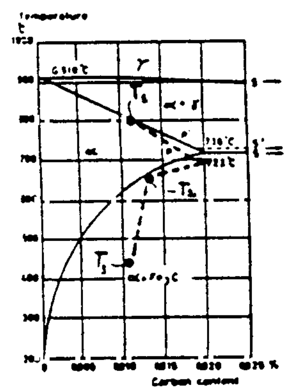


Fig. 5 Solubility field for carbon in α-iron

The advantage of the ZINQUENCH-thermal cycle by increasing the annealing time:

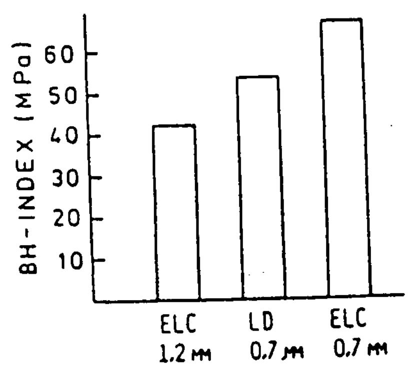
- better formability of coated steel strip and uniformity on the mechanical properties
- possibility to reduce the annealing temperature: lower fuel consumption or
- to increase the capacity of the line

ZINQUENCH combined with a new furnace-design makes it POSSIBLE to over-age continuously in the line without two separate operations:

$\left.\begin{array}{l}\text{- batch post-annealing} \\ \text{- post temper-rolling}\end{array}\right\}$ expensive operation

4.3 Bake hardenability

In the ZIEGLER-line steel strip was cooled slowly after the zinc bath and after the rapid cooling ("mini-spangle" unit) from about 350 °C to 200 °C within about 40 - 60 seconds. Due to the high supersaturation of solute carbon, a very rapid carbide precipitation takes place. Thus over-aging reaction is not completed. The Bake-Hardening Index of the slowly-cooled samples without post-annealing was measured after tensile deformation of 2 pct and baking of 20 min at 170 °C.



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Based on the experiments we believe that ZINQUENCH with the in-line over-aging treatment can produce different grades of bake-hardenable DDQ and HSS-DDQ.

5 High strength steel

ZINQUENCH can produce a new generation of HSLA, which are up to now possible to produce using the water-quench cooling technology and coating by the electrogalvanizing.

Advantages:

- uniformity;	uniform thermal treatment (conventional; some grades are partly recovery annealed)
- weldability;	- low-alloyed steel compositions, (- rephosphorized)
- non-aging;	in-line over-aging and high carbide density
- dual-phase steel;	- low cost - low-alloy Mn_{eq} about 1,3 %; - perfect zinc coating adherence

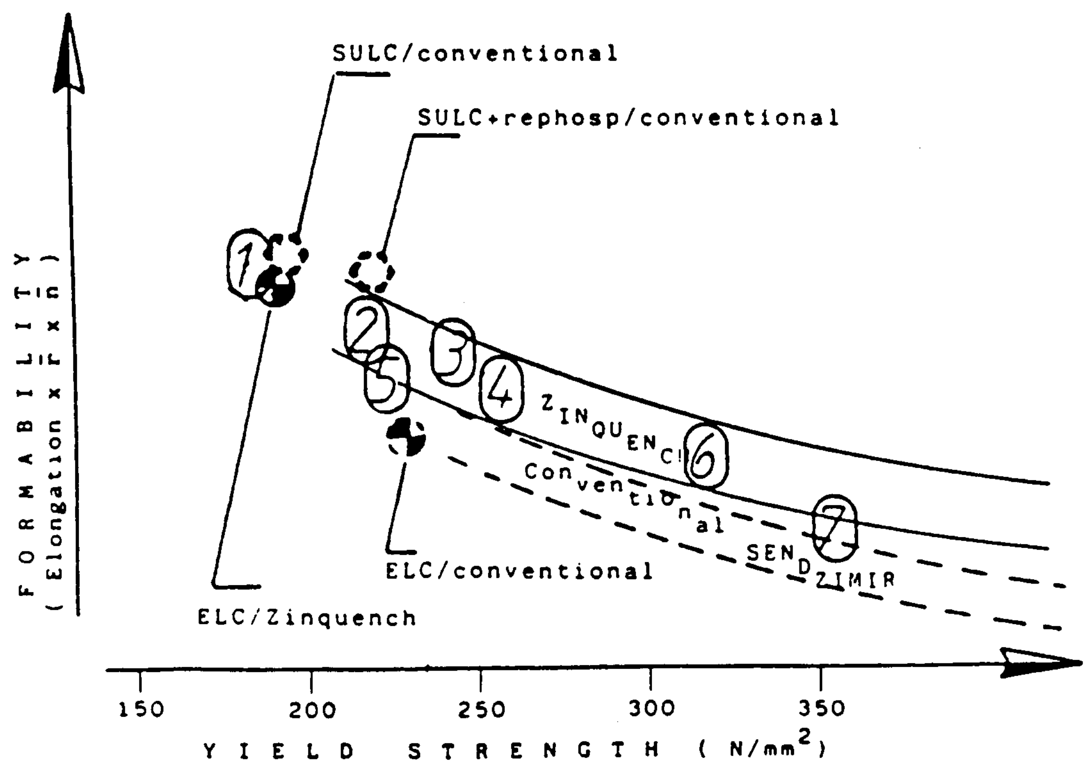
PS 10.2.87

Automotive design and materials selection by G. Davies and R. A. Easterlow; Metals and Materials, January 1985.

Application and properties of various materials used in automobile bodies

	ALTERNATIVE TO MILD STEEL					REQUIRED PROPERTIES (MINIMA)		A_{50}		
	PANEL		CURRENT CHOICE	PREFERRED CHOICE		YIELD STRESS (N/mm²)	UTS (N/mm²)	ELONGATION (% on 50mm)	r DRAWING INDEX	n STRETCH FORMING INDEX
1	Roof		Mild steel	Mild steel		180	310	50 (Typical)	1.8	0.23
	Bonnet	Inner	Rephosphorised	Bake hardening	As received	210	355	36	1.5	0.20
		Outer	"	"						
	lid	Inner	"	"						
		Outer	"	"						
2	Doors	Inner	Low YS rephosphorised	"	Post paint bake	255 (2% deformation + 30 min at 170°C) *)	360	–	–	–
		Outer	Rephosphorised	"						
	Panel Front Lower		"	"						
	Rear Lower		"	"						
	Sills		Rephosphorised	"						
	Fenders		Low YS rephos	"						
3	Hoodside		Low YS rephos	Low YS rephos		225*	350	35	1.7	0.20
	Dash		"	"						
	Valance/wheelhouse		"	"						
	Wheel arches		"	"						
4	Main floor		Rephosphorised	Rephosphorised		255*	360	32	1.6	0.18
	X member - Complex		"	"						
	A post		"	"						
	B/C post Outer		"	"						
	Closing		"	"						
5	Rear members		"	Low YS dual phase		320	440	18	1.2	0.14
6	Rear floor		"	Dual phase		320	600	26	1.0	0.22
	Front longitudinals		"							
	Rear longitudinals		"							
	Door beams		HSLA	High YS dual phase		550	950	9	0.8	0.12
7	Crossmembers - Simple		HSLA	HSLA		350	450	23	1.1	0.19
	Suspension towers		HSLA	HSLA						
	Jacking brackets		HSLA	HSLA						
	Small structural reinforcements		HSLA	HSLA						

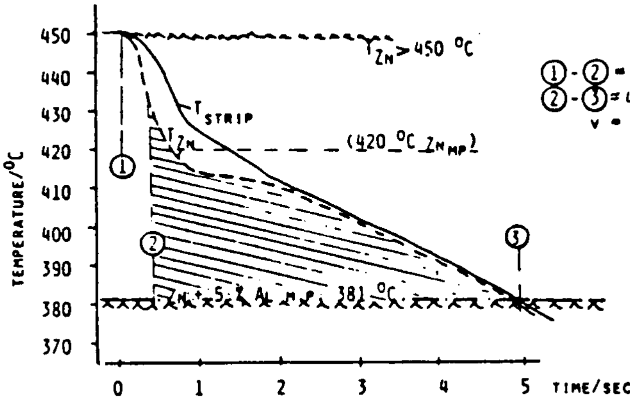
Bake-Hardening needs continiuous O.A.-furnace

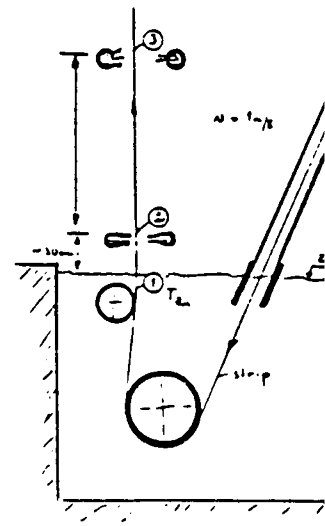


7 Galfan - coating

THE CONVENTIONAL - ATMOSPHERE GAS -METHOD:

- to avoid uncoated spots → high bath temperature



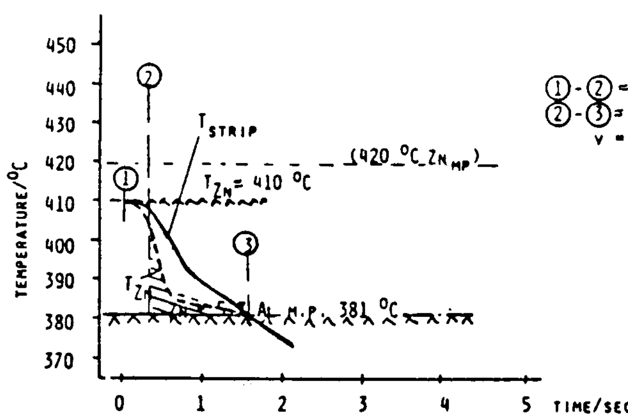


Problems:

- large grain-size
- grain boundary dents

THE ZINQUENCH-METHOD:

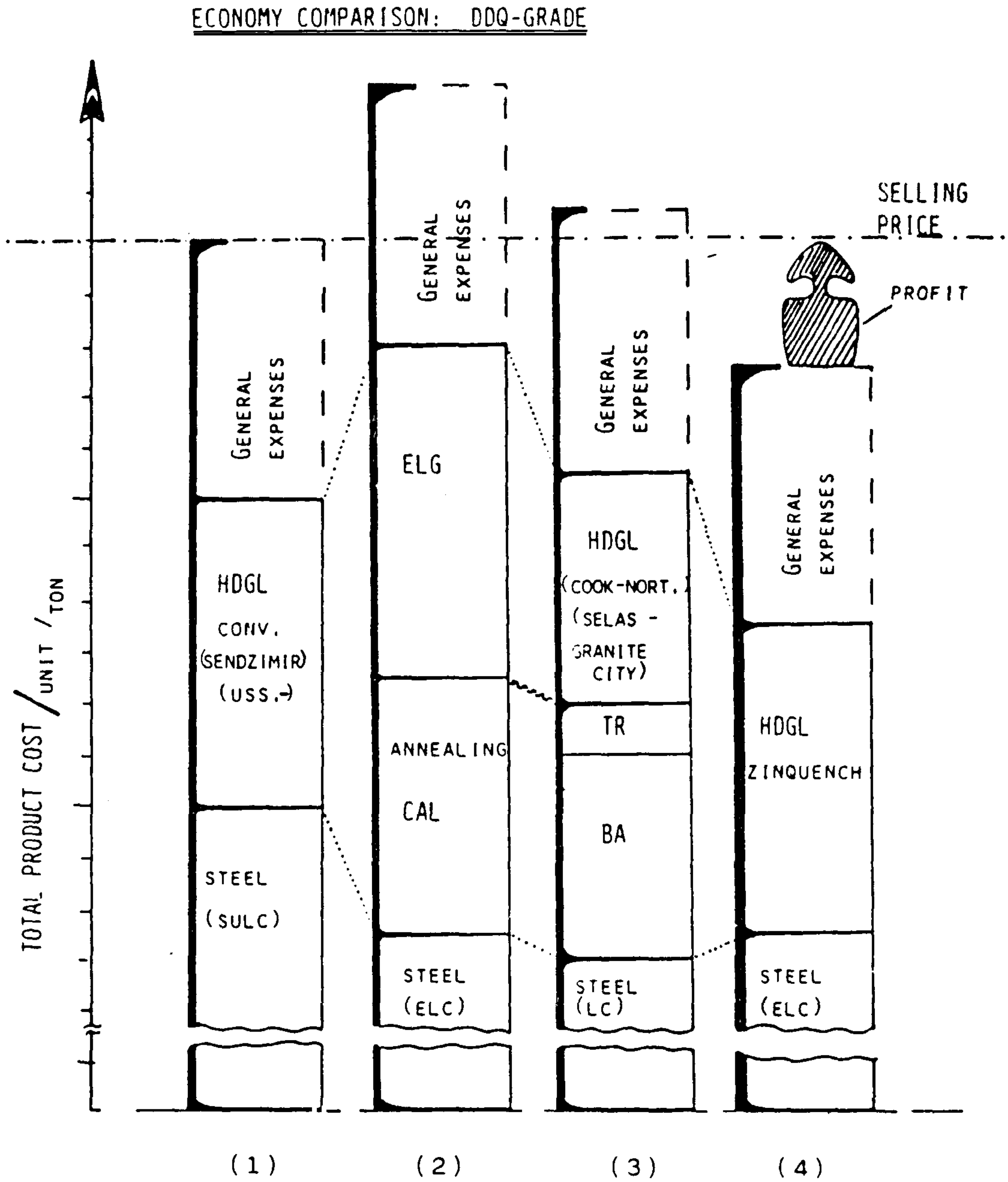
- bath temperature 410 - 420 °C



Advantages:

- fine grain-size
- no uncoated spot
- good coating aspect

8 Production costs of zinc coated, deep drawing quality steel sheet produced by various technologies



(1)	Conventional - atmosphere gas - hot-dip method
(2)	Electrolytic coating method with separate annealing operation; continuous annealing or batch annealing and temper-rolling
(3)	Flux-based hot-dip method or preheating method with separate annealing operation (BA) and temper-rolling (TR)
(4)	Zinquench - atmosphere gas - hot-dip method

PRODUCT MIX: MANUFACTURING PRACTICES OF CONVENTIONAL HOT-DIP METHOD (GAS COOLING E.G. SENDZIMIR-TYPE) AND ZINQUENCH

GRADE	CONVENTIONAL		ZINQUENCH	
	STEEL	GAS COOLING METHOD	STEEL	RAPID COOLING METHOD
DQ	LC +	HDGL + BA + TR	LC +	ZQ
DDQ	SULC +	HDGL	ELC +	ZQ
DDQ + BH	SULC + REPHOS +A SMALL AMOUNT OF SOLUTE CARBON +	HDGL	ELC +	ZQ
HSS (NEW HSLA)	—	—	LC +	ZQ
DP	$Mn_{EQ} \geq 2,0$ % +	HDGL	$Mn_{EQ} \geq 1,2$ % +	ZQ

ZINQUENCH ↔ "HEAT TREATING PROCESS"

HDGL ↔ "ANNEALING PROCESS"

Oil Modification for Longer Protection Against White Rust

An additive has been developed for use with standard SAE 10 oil which lengthens the time of protection against the formation of white rust on steel. This development is an outgrowth of ILZRO sponsored work at Manhattan College conducted by Dr. Max Kronstein. The additive is a liquid containing a by-product of reaction with zinc oxide or zinc dust.

In tests conducted, 1 part of additive was used with 9 parts SAE 10 oil. Samples of both galvanized and Galfan coated sheet steel were exposed to a Cleveland humidity cabinet wet/dry cycle of 3 hours exposure to high humidity followed by 3 hours exposure to dry air.

After one year of exposure in the Cleveland humidity cabinet, Galfan panels did not exhibit corrosion according to Dr. Kronstein. They were believed to be suitable for painting after removal of the remaining protective oil coating.

Laboratory samples are available for testing and evaluation. Arrangements can be made for commercial manufacture of the product by an interested producer. For further information contact:

Dr. Dodd S. Carr
International Lead Zinc Research Organization, Inc.
P.O. Box 12036
Research Triangle Park, NC 27709-2036
(919) 361-4647

INTERNATIONAL LEAD ZINC RESEARCH ORGANIZATION, INC.

2525 MERIDIAN PARKWAY
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RESEARCH TRIANGLE PARK, N.C. 27709-2036
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FACSIMILE: (919) 361-1957

ILZRO Project ZM-285

Continuous Galvanizing of Steel Sheet

STATUS OF GALFAN PATENT ESTATE

Date: May 12, 1987

Prepared By: Dr. Dodd S. Carr, Manager,
Chemistry, Electrochemistry, and Patents

PROJECT NO. ZM-285

CONTINUOUS GALVANIZING OF STEEL SHEET		Page 1 of 3

Invention: Zinc-Aluminum Alloys and Coatings

Inventors: Schrade F. Radtke, Dimitri Coutso
Jacques Pelerin*

Attorney's File No.		Filing Date	Serial No.
24490	United States	03-18-81	245,172
24490A	United States	08-02-82	404,405
F24490	Argentina	01-04-82	288,029
F24490	Australia	03-18-81	70796/81
F24490	Austria	03-18-81	E48,270
F24490	Belgium	03-25-80	C20-26/8003
	Belgium	01-16-81	C21-07/8101
F24490	Brazil	11-24-81	PI81 07944
F24490	Canada	03-24-81	373,746
F24490	Czechoslovakia	01-15-82	PV.323-82
F24490	East Germany	01-15-82	APC 22 C/236 795/5
F24490	European (EPC)		81-901054.7**
F24490	Finland	11-20-81	813,715
F24490	France	03-18-81	E0048270

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* Addresses: Radtke: 76 Soundview Lane, New Canaan, CT 06840
Coutsouradis: Orban 10/071, 4020 Liege, Belgium
Pelerin: Des Grosses Battes 51/16, 4900 Angleur, Belg

PROJECT NO. ZM-285

CONTINUOUS GALVANIZING OF STEEL SHEET

Attorney's File No.		Filing Date	Serial No.	Pa
F24490	India	12-21-81	1437/Cal/81	
F24490	Italy	12-30-81	68730-A/81	
F24490	Japan	03-18-81	501400/1981	
F24490	Korea	12-29-81	5,198/1981	
F24490	Liechtenstein	-See European (EPC)-		
F24490	Luxembourg	03-18-81	E48,270	
F24490	Mexico	01-15-82	9872	
F24490	New Zealand	01-14-82	199,491	
F24490	Netherlands	03-18-81	E48,270	
F24490	Poland	02-24-82	P235,209	
F24490	Russia	11-24-81	336.1151/02	
F24490	South Africa	01-07-82	82/0091	
F24490	Spain	01-15-82	508,771	
F24490	Sweden	03-18-81	81-901,054.7	

PROJECT NO. ZM-285

CONTINUOUS GALVANIZING OF STEEL SHEET

Attorney's File No.		Filing Date	Serial No.	Pa
F24490	Switzerland	03-18-81	E48,270	
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F24490	United Kingdom	03-18-81	E48,270	
F24490	West Germany	03-18-81	P3171 770.5	
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ILZRO Project ZM-285

Continuous Galvanizing of Steel Sheet

REGISTRATION STATUS OF TRADEMARK "GALFAN"

Date: May 12, 1987

Prepared By: Dr. Dodd S. Carr, Manager,
Chemistry, Electrochemistry, and Patents

PROJECT NO. ZM-285

CONTINUOUS GALVANIZING OF STEEL SHEET

Registration of the Trademark "GALFAN"
(Brumbaugh File L4276-80/4778)

Country	Filing Date	Serial No.	Trademark Regist
United States of America	11-01-85	73/566,270	1,414,72
Australia	07-29-81	402,160	
Austria	12-22-86	4175/86	
Benelux	08-04-81	644,356	375,388
Bophuthatswana	03-19-84	84/0177	84/0177
Canada	07-28-81	473,239	~~533,673~~
Finland	07-09-84	235/84	92,853
France	10-02-81	609,591	1,184,19
Great Britain	07-31-81	1,158,613	
Italy	10-27-81	22.133 C/81	
Japan	10-06-81	84488/1981	
New Zealand	01-10-84	150,709	150,709
Norway	01-10-84	84.0080	119,540
South Africa	01-10-84	84/0191	84/0191

Registration of the Trademark "GALFAN"
(Brumbaugh File L4276-80/4778)

Country	Filing Date	Serial No.	Trademark Registra
South West Africa	03-18-84	84/0168 (SWA)	84/0168 (
Sweden	07-31-81	81-3991	181,144
Taiwan	12-20-86	(75) 62,661	
Transkei	03-24-84	84/0183	84/0183
Venda	03-19-84	84/0173	
West Germany	07-31-81	J 16946/6Wz	1,049,001
Yugoslavia	02-17-84	Z-66/84	

GALFAN • DATA • SHEET

How does Galfan compare?

5 = Best
1 = Worst

	Galfan	Hot Dip Galvanized	Electrogalvanized	Galvanneal	Galvalume	Aluminized	Zincrometal
Formability	5	3	5	3	3	2	5
Corrosion Resistance (bare)	4	3	3	2	5	5	2
Sacrificial Protection	5	5	5	5	3	1	2
Corrosion Resistance (formed)	5	3	3	3	3	2	2
Paint Adhesion	5	4	5	5	4	2	5
Corrosion Resistance (painted)	5	4	4	5	3	3	2
Weldability	3	4	5	5	2	1	2
Heat Resistance/Reflectivity	3	3	3	2	4	5	1
Relative Cost	3	4	2	4	3	3	5

Galfan® is a new generation coating for steel that both improves product performance and significantly expands manufacturing capabilities.

Containing 95% zinc and 5% aluminum/mischmetal, Galfan provides a unique combination of coating benefits including:

• Maximum Formability •
• Increased Corrosion Protection •
• Full Sacrificial Protection •
• Improved Paintability •
• Good Weldability •
• Broad Versatility •
• Excellent Surface Smoothness •

Is Galfan the coating for your application? The table above will help you make a decision. It charts how Galfan stacks up to other coated steels commonly available.

The coated products are rated on a relative basis, considering normal performance levels in each category. Product and performance characteristics are defined on the other side of this sheet.

Where has Galfan proved successful? The list includes a variety of applications in such industries as:

• Construction •
• Pre-Engineered Metal Buildings •
• Fencing •
• Agriculture •
• Automotive •
• Appliance •
• Industrial Equipment •

The comparison above is intended to provide general guidance to users for applications in a broad range of industries. Specific properties of a particular material should be determined by contact with the supplier of that coated steel product. All of the products are rated as normally supplied and used.

G A L F A N ◦ D A T A ◦ S H E E T

Coated Steel Products Defined

Galfan — A 95% zinc-5% aluminum-mischmetal alloy hot dip coated steel product. Available in a full range of coating weights from GF01 to GF235 (700 g/m²) per ASTM A875.

Hot Dip Galvanized — Standard hot dip zinc coated steel product. Available in a full range of coating weights from G01 to G235 (700 g/m²) per ASTM A525. Produced with regular spangle, minimized spangle and extra smooth surface finish. Differentially and one side coated product is available.

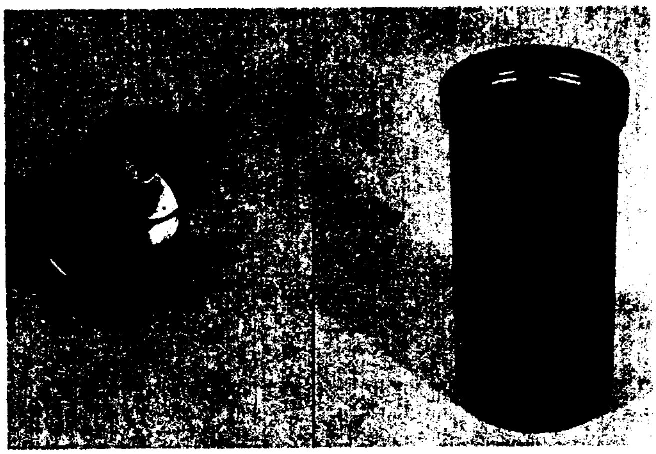
Electrogalvanized — An electrolytic zinc coated steel product. Available in coating weights up to a practical maximum of G60 (180 g/m²). Differentially and one side coated product is available, as is zinc-iron electrogalvanized.

Galvanneal — A zinc-iron alloy hot dip coated steel product. Produced by heat treating or wiping the surface of hot dip galvanized sheet. Available in coating weights from A01 to A60 (180 g/m²) per ASTM A525 and as a differentially coated product.

Galvalume — A 55% aluminum-1.5% silicon-43.5% zinc hot dip coated steel product. Available in coating weights from AZ50 (150 g/m²) to AZ60 (180 g/m²) per ASTM A792.

Aluminized — A hot dip aluminum coated product. Available as Types 1 and 2 in different coating weights per ASTM A463.

Zincrometal — A two-layer coil coated product. It consists of a base coat, containing primarily chromium and zinc, topped with a weldable zinc-rich primer.



Housing for car door lock motor demonstrates Galfan's unique combination of superior formability and improved corrosion resistance.

Performance Characteristics of Coated Steel Products

Formability — Measure of the ability of the coating to survive fabrication operations such as bending, roll forming, stamping and deep drawing without cracking, flaking or failure of the coating.

Corrosion Resistance (bare) — Measure of the time the coating can protect the underlying steel and resist red rust corrosion in normally encountered environments. The length of corrosion protection given by zinc coatings depends directly on coating thickness.

Sacrificial Protection — Ability of the coating to provide galvanic or sacrificial protection to bare steel exposed at cut edges, fastener locations, scratches, etc in normally encountered environments. Aluminized and Galvalume coatings provide good extended sacrificial protection only in salt environments when the aluminum becomes sacrificially active.

Formed Product Corrosion Resistance — Ability of fabricated products containing sharp bends and deep drawn sections to resist corrosion.

Paint Adhesion — Ability of the coating to be painted using a wide variety of pretreatment, primer and top coat systems and to maintain good adhesion during product fabrication and use.

Painted Product Corrosion Resistance — Ability of the commercial coil coated product to protect the base steel from red rust including blistering, edge creep corrosion and red rust staining.

Weldability — Ability of the coated steel to be spot welded on a continuing basis with good welding electrode life.

Reflectivity/Heat Resistance — Measure of relative brightness and heat oxidation resistance upon exposure to elevated temperatures.

Cost — Relative production cost of material per ton.

WEIRTON
STEEL CORPORATION

GALFAN CASE HISTORY

APPLICATION: Prepainted Wood Grain Embossed Garage Door

END USER: Haas Door Co.

REASONS FOR GALFAN CHOICE:

1. Compatability with polyurethane foam.
2. Ability to withstand post-embossing while maintaining excellent paint film integrity.
3. No flaking or microcracking of the coating.
4. Improved corrosion protection and formability over galvanized.
5. Resistance to edge creep, paint crazing and blistering.
6. Low maintenance associated with precoated steel.
7. Ability to withstand micro V-grooving which provides added strength.

GALFAN SPECIFICATION:

.010 x 23.1875 LFQ, GF-60, NCT, Oil, Off Line
.010 x 26.1875 LFQ, GF-60, NCT, Oil, Off Line
.015 x 23.1875 LFQ, GF-60, NCT, Oil, Off Line
.015 x 26.1875 LFQ, GF-60, NCT, Oil, Off Line

Polyester topcoat
Epoxy primer
Dried in place chromate

A. B. Celestin
Manager - Marketing

ABC/np

WEIRTON STEEL CORPORATION/400 THREE SPRINGS DRIVE/WEIRTON, WEST VIRGINIA 26062-4989 PHONE (304) 797-2000

ZINC COATED STEEL SHEET AND STRIP

GM6185M - HOT DIP GALVANIZED AND GM6201M - ELECTROPLATED ZINC

1 SCOPE. These specifications cover the requirements for cold-rolled carbon steel sheet and strip unless otherwise specified, i.e. hot rolled, high strength low alloy, etc., subsequently zinc coated (galvanized) by the hot-dip process (GM6185M) or by electroplating (GM6201M). Provision is made for specifying a variety of coating masses each with a selection of finishes to satisfy various performance and appearance requirements.

1.1 The type of coating and its mass and finish are specified by suffixes added to basic specification number. The type of coating uses the letter designation "G" for free zinc and "A" for zinc-iron alloy. The coating mass for each side is designated by the minimum value in grams per square meter. The first set of digits along with the letter designation specifies the coating parameters of the unexposed side. The remaining designation specifies the opposite side but is further defined as E (exposed/spangle free), U (unexposed/minimum spangle) or Z (semi-exposed/extra smooth) to depict surface finish. Also see Footnote 1 of Tables 1 and 2. For example: GM6185M (70G20GZ); GM6185M (90G40AU); GM6201M (70G70GE).

1.2 The tables depicting the coating and finish suffixes list common usage. Should other coating masses be required, use the method explained above and only the coating masses of 0, 20, 40, 70, 90 or 98 g/m^2.

1.3 The coating designations used in previous issues of GM6185M shall meet the requirements of this latest specification. Tables 1 and 2 depict the equivalent of designations.

2 DESCRIPTION OF TERMS.

2.1 FREE ZINC. The coating produced in continuous hot-dip or electro-galvanized lines shall consist of not less than 98 percent pure zinc (for coating mass greater than 20 g/m^2 per side) and only minimal alloy layer.

2.2 ZINC-IRON ALLOY. A coating produced by processing the steel through a hot-dip or electro-galvanized line to produce a completely alloyed coating. This product is not spangled, is normally gray in appearance and has a tendency to powder when severely formed.

2.3 REGULAR SPANGLE. A hot-dip galvanized finish resulting from unrestricted growth of zinc crystals during normal solidification. No provision is made in this specification for regular spangle since it is not recommended for automotive applications.

(Continued)

TABLE 1 - GM6185M HOT-DIP GALVANIZED, FREE ZINC

Coating Designation					Coating Mass Per Side, g/m^2, Single Spot Test		Column A (note 2)
Mass Suffix		Finish Suffix (note 1)					
Present	Former	Spangle Free	Minimum Spangle	Extra Smooth	Minimum	Maximum	mm
70G00G	E1	E	U	Z	70/0	120/0	0.02
70G20G	C1	E	U	Z	70/20	120/60	0.02
70G70G	A2	E	U	Z	70/70	120/120	0.05
90G00G	-	E	U	Z	90/0	150/0	0.02
90G20G	-	E	U	Z	90/20	150/60	0.03
90G90G	-	E	U	Z	90/90	150/150	0.04
98G00G	E2	E	U	Z	98/0	160/0	0.02
98G20G	C2	E	U	Z	98/20	160/60	0.03
98G98G	A3	E	U	Z	98/98	160/160	0.05

[1]Spangle free was "W," minimum spangle was "Y" and regular spangle "X" has been deleted and shall be supplied as minimum spangle.

[2]To determine the minimum design steel thickness, use the following formula:

Minimum Design Steel Thickness = Print Specified Minimum Thickness Minus Column A value

Ⓒ Denotes change from previous issue.

	7-85	B	Complete Revision	AEMS EMSP
	6-82	A	Add Non Spangled	AEMS EMSP
	9-78	-	Issued	AEMS EMSP
CONTROL DIVISION	DATE	SYM	REVISION RECORD	AUTHORITY

(Continued)

2.4 MINIMIZED SPANGLE. A hot-dip galvanized finish produced by treating the galvanized sheet during solidification of the zinc to restrict the normal spangle formation.

2.5 EXTRA SMOOTH. A hot-dip galvanized finish produced by "skin passing" the coated steel sheet to impart a higher degree of smoothness than is normal for as-coated products.

2.6 SPANGLE FREE. A hot-dip galvanized finish produced by eliminating all visual spangle pattern. Used for critical appearance applications.

2.7 DIFFERENTIAL COATED. A hot-dip or electro-galvanized sheet or strip having one coating mass on one side and a significantly different coating mass on the other side. The product is available as differentially coated free zinc (both sides), zinc-iron alloy (both sides) or with free zinc on one side and zinc-iron alloy on the opposite side.

2.8 COATED ONE SIDE. Hot-dip or electro-galvanized sheet or strip with one surface completely free of coating.

3 BASE METAL. Base metal furnished to these specifications shall be UNS G10080 (SAE 1008) for drawing quality types or G10090 (SAE 1009) for commercial quality cold-rolled carbon steel sheet or strip unless otherwise specified. Mechanical, physical and other properties conforming to the limits established for the quality of sheet or strip may also be specified by the purchaser. The coated product shall be capable of being fabricated into an identified part.

3.1 MATERIAL THICKNESS. The specified material thickness for both hot-dipped and electroplated coatings includes the steel and the coating as the total thickness. See GM6160M for preferred thicknesses.

NOTE: To determine the minimum design steel thickness, see Column A of Tables 1, 2 and 3.

4 COATING AND FINISH. Coating mass and finish shall conform to the appropriate requirements prescribed in Tables 1, 2 and 3.

4.1 MAXIMUM COATING MASS. If the initial testing produces a value more than the specified maximum shown

(Continued)

TABLE 2 - GM6185M HOT-DIP GALVANIZED, ZINC-IRON ALLOY

Coating Designation				Coating Mass Per Side, g/m² , Single Spot Test		Column A (note 2)
Mass Suffix		Finish Suffix (note 1)				
Present	Former	Exposed	Unexposed	Minimum	Maximum	mm
40A40A	B2	E	U	40/40	90/90	0.02
70A20A	D2	E	U	70/20	120/60	0.02

[1]Exposed (E) was "W" and unexposed (U) was "Z."

[2]To determine the minimum design steel thickness, use the following formula:

Minimum Design Steel Thickness = Print Specified Minimum Thickness Minus Column A Value

TABLE 3 - GM6201M ELECTROPLATED ZINC (ELECTROGALVANIZED)

Coating Designation			Coating Mass Per Side, g/m² , Single Spot Test		Column A (note 2)
Mass Suffix	Finish Suffix (note 1)				
	Exposed	Unexposed	Minimum	Maximum	mm
70G00G	E	U	70/0	80/0	0.01
70G70G	E	U	70/70	80/80	0.02
90G00G	E	U	90/0	100/0	0.01
90G70G	E	U	90/70	100/80	0.02

[1]Exposed (E) was "W" and unexposed (U) was "Z."

[2]To determine the minimum design steel thickness, use the following formula:

Minimum Design Steel Thickness = Print Specified Minimum Thickness Minus Column A Value

(Continued)

in Tables 1, 2 or 3, three additional specimens shall be taken except that the retest specimens shall be taken at least 25 mm from the edge. The average of the three retest specimens must conform to the specified maximum value of Tables 1, 2 or 3.

4.2 COATING BEND TEST. Test specimens of coated metal shall be capable of being bent through 180 degrees in any direction without flaking of the coating on the outside of the bend only. Flaking of the coating within 6 mm of the edge of the bend test specimen shall not be cause for rejection.

4.2.1 Coating bend test specimen shall be 50 to 100 mm wide. The specimens shall be cut not less than 50 mm from the coil edges of the test sheet.

4.3 SIMULATED DRAW BEAD COATING ADHESION. This test is applicable for sheet metal thickness less than 1.25 mm. The coating is acceptable if it exhibits less than 1 percent coating removal per GM9052P.

4.4 COATING SURFACE DEFECTS. Material shall be free from surface defects as negotiated between the supplier and purchaser.

4.5 SURFACE TREATMENT. All steel furnished to this specification shall be coated with a material that meets the requirements of "mill oil and corrosion preventative compounds," and if an edge coating is applied to the steel, it shall meet the requirements of "heavy duty edge coating – outdoor storage" or "light duty edge coating – indoor storage," as shown in Table 4. The zinc coating shall not receive any type of chemical treatment unless specified on the purchase order.

TABLE 4

Product	Surface Coating	Edge Coating	
	Mill Oil	Light Duty	Heavy Duty
One-Side	9981836	9981838	9981837
Two-Side	9981839	9981841	9981840

4.6 SURFACE TEXTURE. Surface texture of the material furnished shall meet the requirements of GM6180M for all exposed (E) suffix designations unless otherwise specified.

4.7 SURFACE PAINTABILITY. The coated surface shall be capable of achieving a high quality zinc phosphate conversion coating (per 9984021 and 9984090) and subsequent superior paint adhesion performance properties.

4.8 CORROSION PERFORMANCE. Performance to this criteria is based on 20 cycles Scab Corrosion Test, 672 hours neutral salt spray and 30 cycles Environmental Corrosion Cycle exposure tests of scribed painted panels as described in Section 8.5. Panels must perform equal to or better than the control standard designated by the purchaser.

5 WELDABILITY. Material furnished to this specification shall be resistance spot weldable as agreed upon by the supplier and purchaser.

6 ADHESION. The coated surfaces of the material furnished shall be adhesively bondable as agreed upon by the supplier and purchaser.

7 MARKING.

7.1 The heavy coated side of differentially coated products shall be identified with markings running the length of the coil at sufficient intervals to assure positive identification of the blank.

7.2 The ink used for marking shall not interfere with welding, phosphating, transfer to the opposite side or print through during part fabrication.

8 TESTS.

8.1 Coating mass is determined by the single spot test as described in ASTM A90. Various acceptable coating stripping methods are available.

8.2 Coating adhesion is tested per GM9052P.

8.3 Surface texture is determined per GM9073P.

8.4 Chemical composition of the steel is determined per ASTM A751.

8.5 Corrosion Tests.

8.5.1 Panels are prepared per Paint Finish, GM4350M, Class A336.

8.5.2 Panels are scribed per GM9102P.

8.5.3 Prepared panels are subject to the following Scab Corrosion Creep Back Test:

8.5.3.1 Place panels at 15° from the vertical with the 300 mm dimension horizontally in a suitable wood or plastic rack.

8.5.3.2 Expose panels for 20 cycles where one week day constitutes one cycle as follows:

(A) Monday
1 hour at 60°C
0.5 hour at −10°C
0.25 hour immersion in 5 percent sodium chloride solution
1.25 hours at room temperature
21 hours humidity at 60°C ± 1°C and 85 percent relative humidity

(Continued)

(Continued)

(B) Tuesday thru Friday
0.25 hour immersion in 5 percent sodium chloride solution
1.25 hours at room temperature
22.5 hours humidity

(C) Saturday and Sunday
Samples remain in the humidity cabinet

8.5.3.3 Visually examine rinsed samples for failures such as corrosion, intercoat adhesion or blistering.

8.5.3.4 Perform air blow off adhesion test per GM9102P.

8.5.3.5 Record lifting, peeling, corrosion creepback and other adverse effects as required by the material specification. Evaluate the scribe line corrosion creepback (loss of adhesion between primer and steel) by measuring the distance between the unaffected primer and the scribe line. Calculate the average of multiple measurements. The number of measurements taken is dependent on the uniformity of the corrosion creepback along the scribe line.

8.5.4 Neutral salt spray tests conducted per GM4298P.

8.5.5 Expose prepared panels to 30 of the following cycles of the Environmental Corrosion Test.

16 hours humidity per GM4465P
2 hours at −30°C
2 hours at room temperature
2 hours at 70°C
2 hours neutral salt spray per GM4298P

NOTE: Samples are left in the humidity cabinet on weekends.

8.5.5.1 Evaluate lifting, peeling, corrosion and any other adverse effects.

9 INITIAL SOURCE APPROVAL. No shipment shall be made by any supplier until representative initial production samples have been tested by the purchaser's laboratory and approved by engineering as meeting the requirements of this specification.

10 INSPECTION AND REJECTION. All shipments of material or parts under contract or purchase order manufactured to this specification shall be equivalent in every respect to the initial samples approved by the purchaser. There shall be no changes in either formulation or manufacturing processes permitted without prior notification and approval by the purchaser. Lack of notification by the supplier constitutes grounds for rejection of any shipment. While samples may be taken from incoming shipments and checked for conformance to this specification, the supplier shall accept the responsibility for incoming shipments meeting this specification without dependence upon purchaser's inspection.

11 APPROVED SOURCES. Engineering qualification of an approved source is required for this specification. Only sources listed in the GM Corporate Material File under this specification number have been qualified by the control division as meeting the requirements of this specification.

Rautaruukki goes for Zinquench

The first commercial example of a new technique for continuous heat treating, quenching and hot-dip coating of steel sheet and strip will be installed in Finland this year, following full-scale trials in France in 1986.

By Heikki Rantanen, Rautaruukki Oy, and Simo Mäkimattila, Rasmet Oy

The Finnish steel producer Rautaruukki has bought the first commercial licence for the Zinquench process for continuous galvanizing of steel sheet and strip. It is to be installed at the company's Hämeenlinna Works in southern Finland at a cost of about £3m.

Zinquench has been recently developed and tested in industrial production trials by another Finnish company, Rasmet. The process is specially designed to treat steels ranging from low-carbon to high strength grades and to impart a zinc-aluminium alloy coating to meet the demand of the automotive and other sheet metal forming purposes.

During 1987 Rautaruukki will modify its one-year-old hot-dip galvanizing line at Hämeenlinna to operate with the Zinquench method, which combines heat treating, quenching and hot-dip coating into a single line operation.

The high cooling rates achieved during quenching into a molten zinc or zinc alloy bath open completely new ways for metallurgical treatment of galvanized strip steels. They also promote the over-ageing reaction of the extra-low-carbon formable steels. This means that hot-dip coated, deep-drawing quality steels can be produced more economically without time-consuming batch-type post-annealing operations. On the other hand, high-strength steels, such as dual-phase and rephosphorised qualities, can also be processed.

In addition, the new process offers some other unique benefits to Rautaruukki. The coatability and mechanical properties of galvanized and plastic coil coated products can be further improved. A considerable amount of Rautaruukki's total galvanized production of 220,000 tpy is finished on the coil coating line where an alloyed coating, such as Galfan, gives significantly better formability and paint adhesion. These properties are important for the manufacturers of wall panels and formed roofing materials. Rautaruukki has traditionally sold its 70,000-tpy colour-coated sheet production to the home market, where the main user has been the building industry.

> **"Full-scale industrial trials were carried out last year at the Mouzon works of Ziegler in France, where the results showed that a defect-free coating with excellent forming characteristics can be produced"**

Rautaruukki's annual output is 1.6m tpy. The largest tonnages, apart from sheet, take the form of hot rolled coil, plate and welded tubes. In the past Rautaruukki concentrated on the development of hot rolled steels for Arctic applications, and in the 1960s it was the first company in the world to achieve 100% continuous casting.

The Zinquench process was developed by Rasmet in three stages. After successful laboratory experiments at the Helsinki University of Technology, a pilot plant unit was built in the Mefos metalworking research plant in Luleå, Sweden.

Full-scale industrial trials were then carried out last year at the Mouzon Works of Ziegler in France, where the results showed that a defect-free coating with excellent forming characteristics can be produced. These trials proved the suitability of the process equipment for the production of both extra-low-carbon deep-drawing steels and high-strength steels.

Rasmet has now entered licensing negotiations with other steel companies around the world. To convert an existing galvanizing line to Zinquench, several modifications must be made. Most of the cooling section has to be changed to an extended annealing zone, leaving only a short gas-cooling section for cooling the strip from the annealing temperature to the desired quenching temperature.

For 95% zinc/5% aluminium alloy either a ceramic or clean cast iron pot is needed, and the pot hardware needs to be of AISI 316L stainless steel to resist the corrosive attack of the melt.

During quenching the hot strip emits a heat equivalent to 45-50kW/tonne, so a line capacity of 20 tph means that excessive heat must be removed at the rate of more than 900kW/hour from the zinc melt. This is done by specially designed sub-surface heat exchangers in the zinc bath.

In Ziegler's prototype equipment the primary coolant is pressurised air: the bath temperature is thus controlled by adjusting the pressure of the air. In the temperature rapid over-ageing treatment to reduce the solute carbon level, so ensuring good anti-ageing properties and excellent formability. Since operation is continuous, good homogeneity compared to the batch-processed strip is achieved.

The Zinquench process, the only available continuous quenching process for galvanizing, can incorporate the continuous over-ageing procedure. Such an in-line type of over-ageing facility will be available on the Rautaruukki line.

The main benefit of the Zinquench process is the possibility of producing a wide range of products. The properties of both deep-drawing grades and

View of the main control room at the Hameenlinna works' hot-dip galvanizing line

secondary heat exchanger the circulated air is cooled by water.

During the Ziegler trials bath temperature was kept stable with constant mechanical stirring, which circulated cooled liquid metal to the zone where the hot strip is immersed. This circulation also guarantees good homogeneity of the coating structure and promotes perfect wetability. During the Ziegler trials no uncoated spots were observed.

Modern continuous annealing lines for cold-rolled sheet steel utilise a low structural steels can be improved — in particular, the formability and ageing resistance of structural steels can be considerably enhanced.

The Galfan coating offers clear advantages compared to conventional zinc coating. In addition to increased corrosion resistance, it has very good forming characteristics combined with good paintability. These properties, together with the improved formability of the zinc-quenched steel, make it a very attractive material. □

Coated Products Division

New Zealand Steel Ltd.

Galvanised Steel Alternative Coatings Bulletin

GALFAN
PERFORMANCE TRIALS

Foreword

New Zealand Steel has over the past 18 months been evaluating the performance of Galfan (5% Aluminium/Zinc coating) both in terms of fabrication characteristics and field performance in mainly rollformed product.

The tendancy worldwide is now towards aluminium/zinc alloy protection rather than straight zinc (galvanised) on the basis of its enhanced corrosion protection and it is with this in mind that New Zealand Steel has once again imported a small tonnage of Galfan with the aim of allowing "all" galvanised users to gain experience with it.

Market place reaction is extremely important at this stage of the evaluation as this will enable any hiccups to be ironed out before any possible future decisions are taken on a commercial basis.

The current evaluation of Galfan in New Zealand is part of a world wide programme to establish its merits and we hope that the industry will be as enthusiastic as us in being a part of this evaluation.

It is our wish that as many end users as possible trial Galfan so that we may monitor its performance on all types of machinery as well as in a multitude of different applications. It is our aim to expose the product to all environments in which galvanised product is currently used as well as those which in the past have been considered "too severe for the coating". Of interest also is its "ease of handling/fabrication" which of course involves such parameters as lubrication requirements and solderability etc.

All product technical data is available from the New Zealand Steel product development team and this relevant information will be passed on at the time of trial.

We thank you for your assistance.

ALTERNATIVE COATINGS TO GALVANISED STEEL

Introduction

The Coated Products Division of New Zealand Steel are currently involved in evaluating various alternative coatings to our current galvanised substrate. (This bulletin describes the current state of that evaluation).

Background

The evaluation has been prompted by a desire to establish an improved service life for both Galvanised and Colorsteel products and to enable New Zealand Steel and its exporting clients to compete with alternative coatings that are already established overseas. This evaluation commenced in the late 1970's and to date has mainly involved laboratory and exposure site testing.

The evaluation series to date has led us to a group of alternative coatings featuring a 5% Aluminium 95% Zinc alloy system. Two of these are Galfan and Superzinc. We have been very impressed with their performance in all respects.

New Zealand Steel is a member of the GALFAN Licensee's group co-ordinated by International Lead Zinc Research Organisation (ILZRO) which entitles us to share and pass on information emanating from 27 other Licensee's throughout the world.

Our confidence in these 5% Al-Zn coatings inspired us to import from Germany and Japan a quantity of Galfan and Superzinc to allow the next stage of our evaluation to begin.

The imported coil will be offered for sale to our clients, under the current standard NZ 3441, the only difference being the coating composition.

We perceive the need to identify every end use where galvanised is currently utilised with a view to offering a 5% Al-Zn coating to ensure compatibility in all respects.

It is envisaged that if a suitable alternative coating is proved, New Zealand Steel would consider offering this coating on all flat products currently in our galvanised range.

Any change in coating will be communicated to the industry well in advance and only after adequate feedback from within the industry has been received. New Zealand Steel does not expect any change to its current galvanised range within the next two years. We have had, and will continue dialogue with relevant statutory bodies such as, SANZ, DSIR, MOWD and BRANZ.

Paint companies have received samples to evaluate as also have sealant suppliers, lead suppliers, fastening suppliers and NZ Master Plumbers Association. Any other interested parties will be provided the opportunity to participate if they so desire. We would welcome your suggestions.

Evaluation Method

Galvanised customers are being approached and invited to participate with us. To ensure a comprehensive evaluation we are recommending the following criteria to the participants.

1) Establish which end use/s will be assessed (as a general guideline it is better to choose the more severe end use environments).
2) Establish the current life expectancy of either galvanised or Colorsteel in that environment.
3) Establish the best system for the environment eg. either painted or unpainted.
4) Once the evaluation material has arrived into Store NZS would like to be involved in all aspects of its processing and field evaluation.
5) Once the finished product is in place it is essential that its precise location is recorded to allow NZS periodic observations to be carried out.

We have compiled the following question/answer sheet to highlight the advantages/ disadvantages of the new 5% Al-Zn coating versus galvanised as we see them.

1. Q. **Why change at all, what's wrong with traditional Galvanised Steel?**

   A. *Traditional Galvanised Steel has obviously served us very well for a great many years. However, there is no disputing the fact that these new 5% Al-Zn coatings are superior in many respects eg. two to four times weathering resistance has been observed in field trials. Also a very substantial reduction in microcracking has been observed which is particularly important for coil coated applications.*

2. Q. **What about price. Will these new coatings be more expensive?**

   A. *Our indications are that production costs will be very similar. However the option of reducing coating weights may well produce a more competitive product with comparable if not better life expectancy.*

3. Q. **Why haven't we had these better coatings before now?**

   A. *Development of new coatings is a long process. In 1967 Bethlehem Steel began development of an alternative galvanised coating to improve service life in the acid rain environment of NE USA.*

   This resulted in the commercialisation of Galvalume/Zincalume in 1972. Development by other companies has continued with Galfan and Super-zinc being produced commercially since 1981.

   NZ Steel has been involved in extensive trials with these new coatings for many years. However before any change is made to an established Galvanised market we have to be very sure of the new product prior to committing the Company and the industry to any change. The final stage of this evaluation is now in progress.

4. Q. **What can't you do with the 5% Al-Zn coating?**

   A. *We believe that the 5% Al-Zn coatings can be substituted for galvanised in all end uses with equivalent or better performance.*

5. Q. **We have heard that you can't solder these alloy coatings?**

   A. *Yes that is true of some types such as Zincalume and Galvalume which have a much higher Aluminium content, (55%). However the 5% Al-Zn alloys are solderable and we are working with flux and solder suppliers on this aspect.*

6. Q. **What about spot welding?**

   A. *The 5% Al-Zn coatings can be spot welded without any equipment modification.*

7. Q. **We have heard that there is a dissimilar metal re-action between lead flashing and these alloy coatings.**

   A. *Zinc and Zinc/Aluminium coatings have similar re-action when in contact with disimilar metals. We believe that if you are using lead with either galvanised or 5% Al-Zn both surfaces should be painted with a recognised barrier primer to prevent metal to metal contact and enhance life expectancy.*

8. Q. **What guarantee do we have that these new coatings are okay?**

   A. *These coatings have been under evaluation by NZ Steel for five years and extensively tested overseas for many years. We believe that extensive field evaluation of this kind is the only sound way to prove the system.*

9. Q. **Will we still have the option of purchasing galvanised if we don't like this new type of coating?**

   A. *We confidently expect the 5% Al-Zn coatings to prove to be most satisfactory in the majority of applications. 100 percent conversion to Galfan would be ideal. Should there remain a small percentage of end uses requiring galvanised then this would be catered for.*

10. Q. **Why do these new coatings go grey more quickly than Galvanised?**

    A. *The 5% Al-Zn alloys do weather and turn grey more quickly, this being the result of surface oxidation forming a protective patina. However once this patina is formed the product is better protected.*

11. Q. **In the event that NZ Steel does effect a change will we be able to mix the two coating types in service?**

    A. *Yes, no problem for technical reasons. There will however be a cosmetic difference because of the differing rates of patina formation.*

12. Q. **Are there any situations that we should avoid with the 5% Al-Zn coatings?**

    A. *In a situation where galvanising is found to be totally unsuitable then 5% Al-Zn is not likely to be suitable either. However, 5% Al-Zn is expected to give a better service life under the same conditions. In these situations we would probably suggest an alternative from our Colorsteel range of industrial finishes. As in the case with galvanising, contact with incompatible materials such as copper should be avoided.*

13. Q. **Will the cut edge protection be diminished by the 5% Al-Zn coatings?**

    A. *We have found no apparent difference in cut edge protection with 5% Al-Zn alloy coatings. However there is a noticeable loss of protection with the 55% Al coatings. It stands to reason that if 100% zinc provides the best protection and you dilute the zinc content to say 45% then the cut edge protection will be significantly reduced. This is one of the reasons why we believe the 5% Al-Zn alloy coatings will be better for New Zealand conditions.*

Summary

It is obvious that any change to an alternative coating system will result in many questions being raised from all sectors of the community, which will require considered and accurate answering. To achieve this New Zealand Steel needs and indeed desires your co-operation in the evaluation of Galfan trial material.

INDUSTRIAL WIRES. ACCELERATED TEST PROGRAM

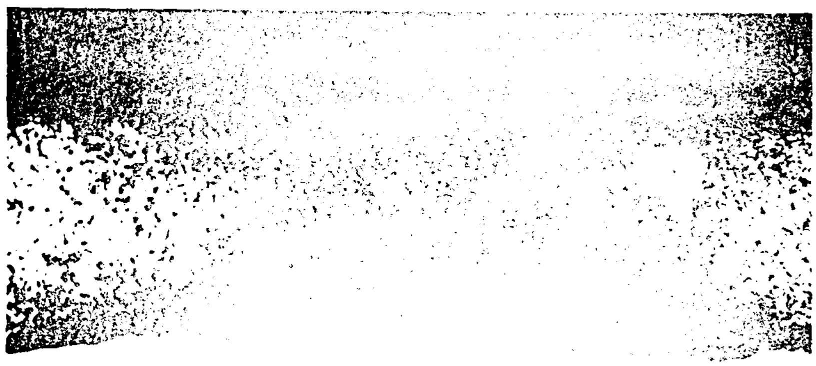
COATINGS CHARACTERISTICS

REF.	COATING	DIP	WIRE DIAM (MM)	COATING THICK (µM)	PB CONTENT (PPM)
B1	GALFAN	1	2,2	35	20
B2	GALFAN	2	2,2	45	20
B3	GALFAN	2	2,2	46	120
B4	GALVA		2,2	49	50
FZ	GALVA		1,8	41	600
FG	GALFAN	2	1,8	30	340

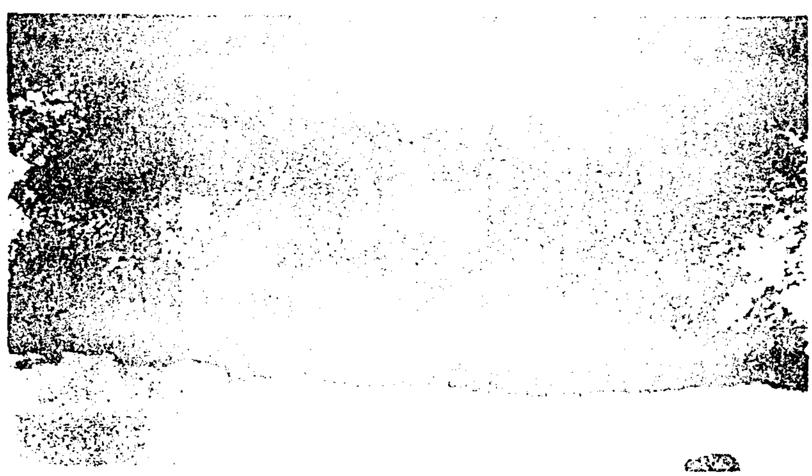
INDUSTRIAL WIRES - ACCELERATED TESTS PROGRAM

COATINGS STRUCTURE (500x) OF GALFAN

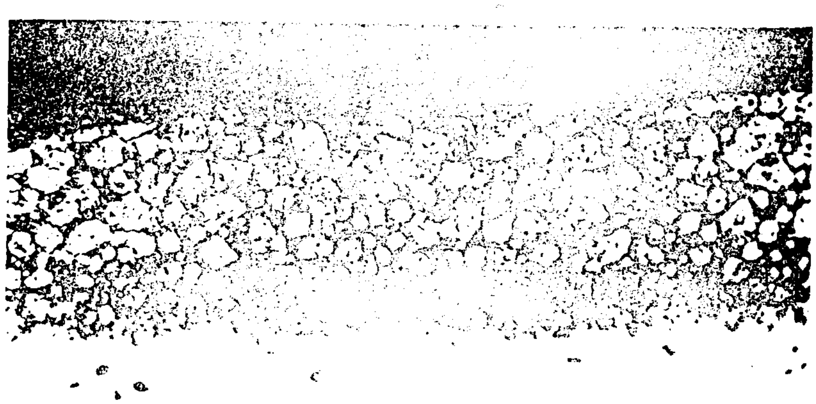
DIP



SINGLE (B1)



DOUBLE (B2)

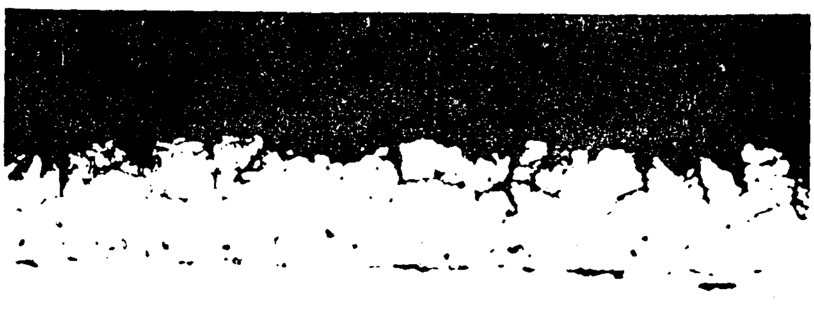


DOUBLE (FG)

INDUSTRIAL WIRES - SALT SPRAY TEST

COATING : GALFAN SINGLE DIP (B1)

EXPOSURE
(DAYS)



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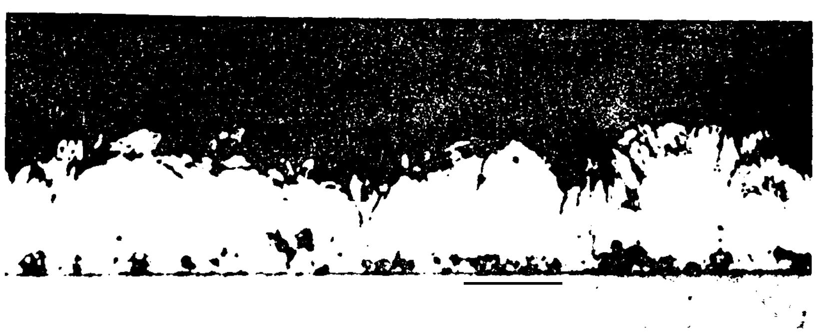

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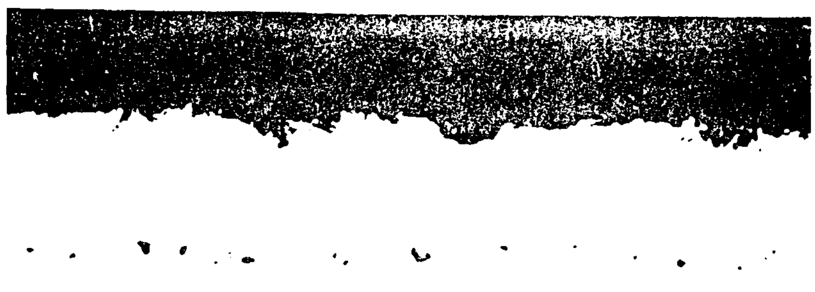
INDUSTRIAL WIRES - SALT SPRAY TEST

COATING : GALFAN DOUBLE DIP LOW PB (B2)

EXPOSURE
(DAYS)



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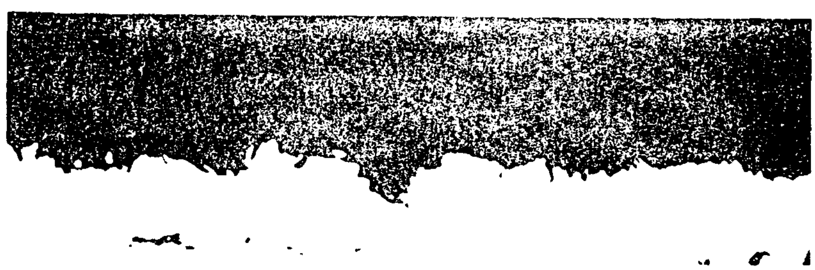

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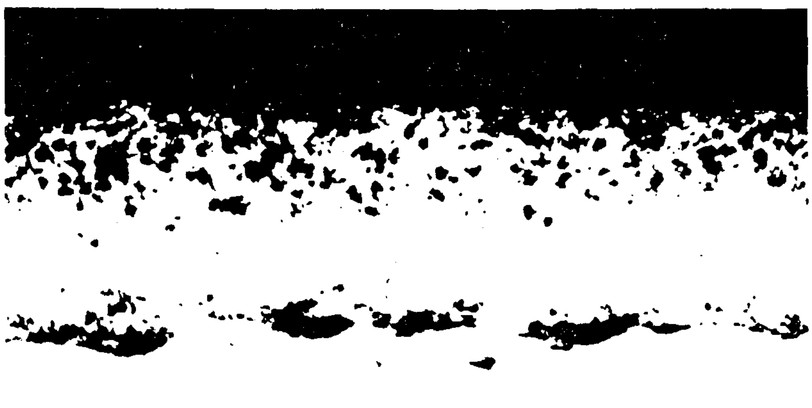
INDUSTRIAL WIRES - SALT SPRAY TEST

COATING : GALFAN DOUBLE DIP HIGH PB (B3)

EXPOSURE (DAYS)



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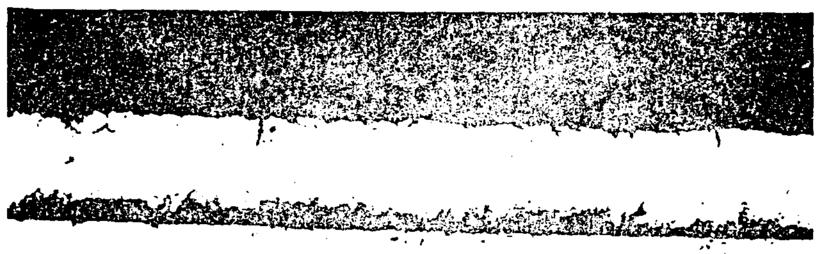
8

INDUSTRIAL WIRES - SALT SPRAY TEST

COATING : GALFAN DOUBLE DIP HIGH PB (FG)

EXPOSURE
(DAYS)



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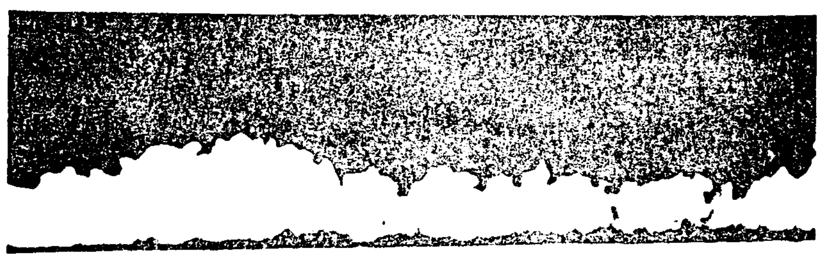

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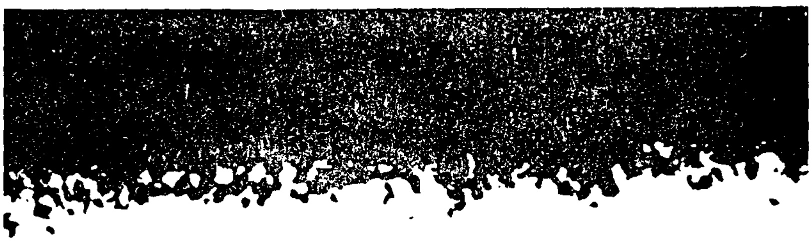
INDUSTRIAL WIRES - SALT SPRAY TEST

COATING : GALVA (B4)

EXPOSURE

(DAYS)



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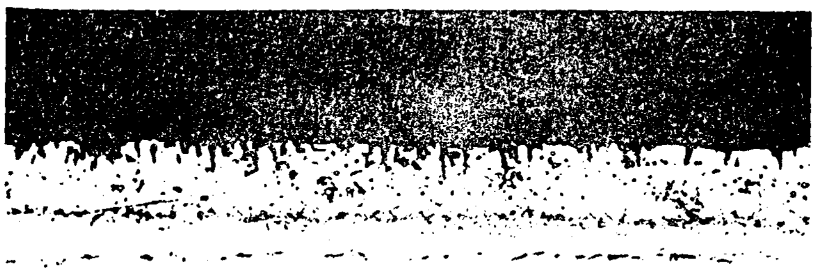
8

INDUSTRIAL WIRES - SALT SPRAY TEST

COATING : GALVA (FZ)

EXPOSURE

(DAYS)



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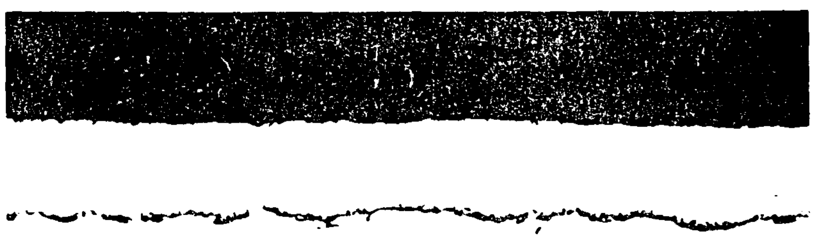
8

INDUSTRIAL WIRES - HUMIDITY CABINET

COATING : GALFAN SINGLE DIP (B1)

EXPOSURE (DAYS)



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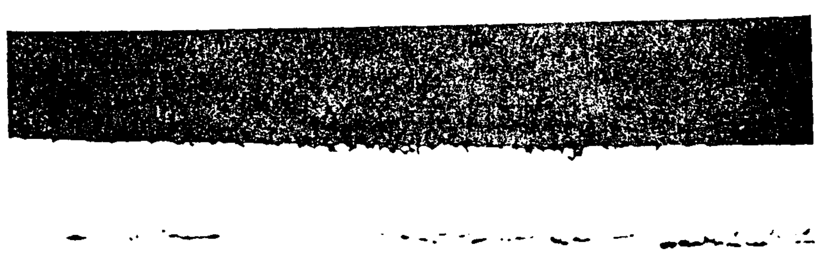
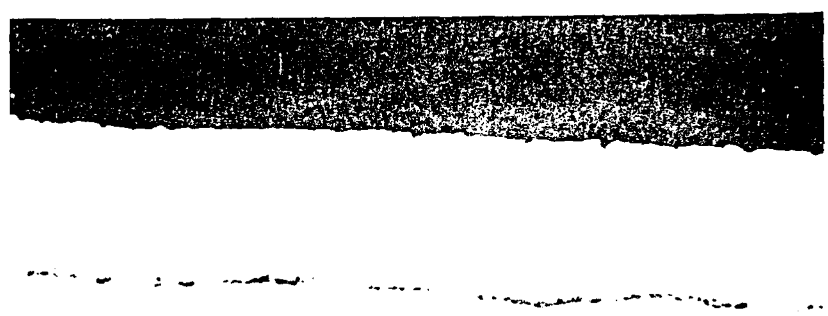


17

INDUSTRIAL WIRES - HUMIDITY CABINET

COATING : GALFAN DOUBLE DIP LOW Pb (B2)

EXPOSURE (DAYS)



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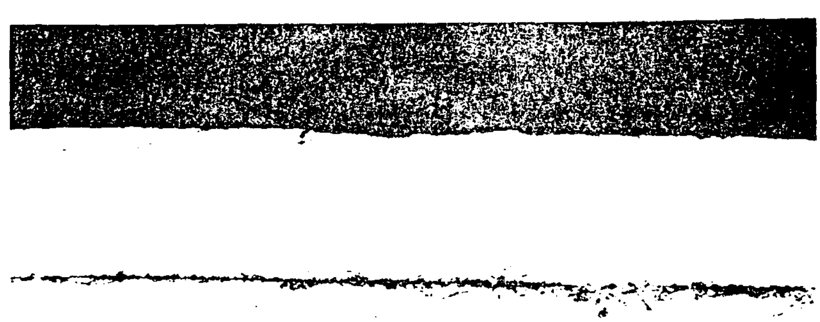
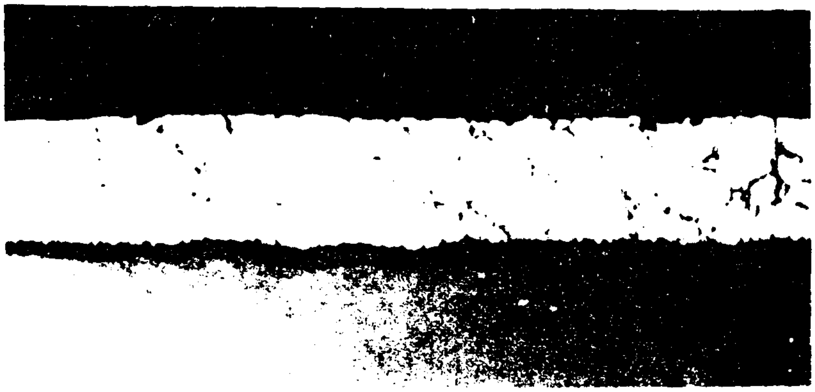


17

INDUSTRIAL WIRES - HUMIDITY CABINET

COATING : GALFAN DOUBLE DIP HIGH Pb (B3)

EXPOSURE (DAYS)



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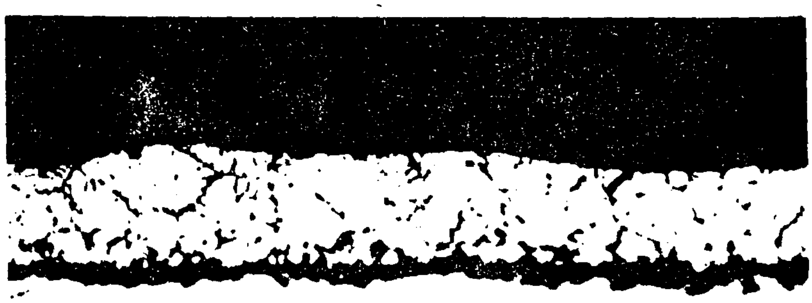


17

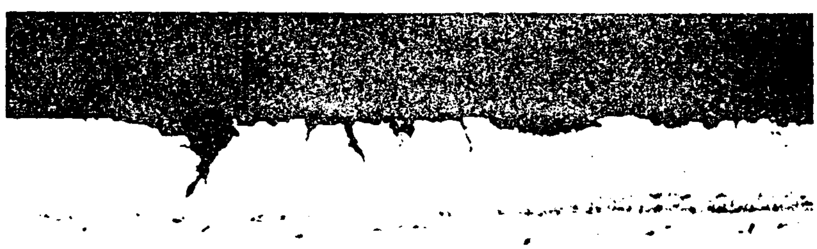
INDUSTRIAL WIRES - HUMIDITY CABINET

COATING : GALFAN DOUBLE DIP HIGH PB (FG)

EXPOSURE
(DAYS)

5

(250x)



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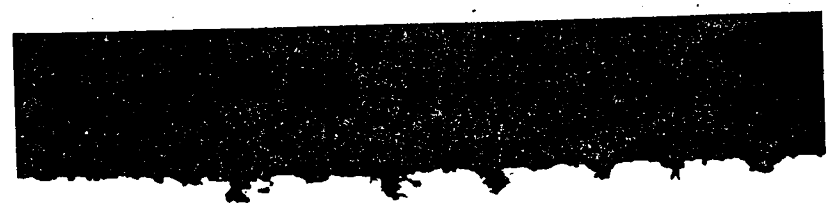
EXPOSURE
(DAYS)

5

(250x)



17

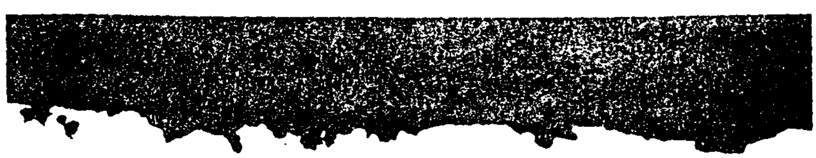
INDUSTRIAL WIRES - HUMIDITY CABINET

COATING : GLAVA (FZ)

EXPOSURE
(DAYS)

5

(250x)



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