NINTH GALFAN LICENSEES MEETING
November 11 - 13, 1986
Siegen, West Germany
Confidential to Licensees

INTERNATIONAL LEAD ZINC RESEARCH ORGANIZATION, INC.

MINUTES OF THE NINTH GALFAN LICENSEES MEETING OPERATING SESSION

Held At

Siegen, West Germany

On

November 12, 1986

ATTENDANCE

NAME	COMPANY	PRODUCTION	RESEARCH	MARKETING
J. Alfano	Stelco	X	X	X
J.J. Brinsky	Weirton Steel	X	X	X
J. Brugarolas	Procoat	X	X	X
E. Buscarlet	Ziegler	X	X	
A.B. Celestin	Weirton Steel	X	X	X
N. Clark	New Zealand Steel	X	X	X
D. Coutsouradis	CRM	X	X	X
A. D'Autilia	Industrie Cantieri Metallurgici Italiani	X	X	X
A. Davin	CRM	X	X	X
M. Dewitte	Bekaert	X	X	
R.A. Ewing	Weirton Steel	X	X	X
J.C. Farge	Noranda	X	X	X
H.P. Ferret	Fical			X
B. Francois	Galvanor	X	X	
A. Fuchs	Hoesch - Stahl	X	X	X
L. Furke	Hoesch - Stahl	X	X	
B. Galliez	F.F.M.	X	X	
S.G. Ghosh	H.K. Coated Sheets	X	X	X
F.E. Goodwin	ILZRO	X	X	X
Y. Hirose	Nisshin Steel	X	X	X
Y. Hoboh	Sumitomo Metal	X	X	X
K. Iwanuma	Kawasaki	X	X	X
D. Jones	British Steel Corp.	X	X	X
I. Kamimura	Nisshin Steel	X	X	X
M. Kato	Kawasaki	X	X	X
J.E. Lait	Stelco, Inc.	X	X	X
B. Lambert	Fical			X
J. Lamesch	Arbed	X		X
A. Limare	Penarroya	X	X	X
E.C. MacKinnon	Stelco, Inc.	X	X	X
H. Marusima	Kawasaki	X	X	
A. Mathews	British Steel Corp.	X	X	X
T. Ng	New Zealand Steel	X	X	X
T. O'Donnell	Stelco, Inc.	X	X	X

NAME	COMPANY	PRODUCTION	RESEARCH	MARKETING
M. Ota	Sumitomo Metal		X	X
C. Parma	Cotimpi			X
P. Pellerin	Phenix Works		X	
P. Piessen	Centre Technique Du Zinc	X	X	
V. Polard	Phenix-Works	X	X	
B. Renaux	CRM	X	X	X
V. Rispoli	Industrie Cantieri Metallurgici Italiani	X	X	X
C.E. Roberts	ILZRO	X	X	X
R.I. Robertson	Noranda			
F. Rodellas	Procoat	X	X	X
H. Schneider	Hoesch - Stahl			X
W. Schwarz	Hoesch - Stahl	X	X	X
R. Sempels	Vieille-Montagne	X	X	X
V. Sipila	Outukumpu Oy	X	X	X
P. Sippola	Rasmet	X	X	X
A.F. Skenazi	M.H.O.	X	X	X
R. Sokolowski	VMAF	X	X	X
K.K. Somani	H.K. Coated Sheets	X	X	X
R.K. Somani	H.K. Coated Sheets	X	X	X
J.A. Southern	AM&S Europe			X
A. Stoneman	Zinc Development Ass.	X	X	X
A. Szydlik	Salmax	X	X	
M. Taylor	AM&S Europe	X	X	X
J.P. Thill	Eurinter/Phenix Works			X
C. Vanden Bussche	Bekaert	X	X	
H. Wagener	Arbed		X	X
D. Ward	Zinc Development Ass., London			X
W. Warnecke	Thyssen Stahl	X		
B. Wolf	Hoesch - Export			X
R. Zwingmann	Hoesch - Stahl	X	X	X

MEETING CONVENED

The meeting was convened by Dr. Goodwin, Chairman, at 9:30 a.m. He welcomed the licensees to this first meeting of the licensees in West Germany and gave thanks to Hoesch for their sponsorship of the very successful plant tour which had been held the day before. He noted that Hoesch had been very openhanded with the information on their GALFAN production techniques and urged that the licensees present here follow the same spirit of open-handedness during the operating session. Following this, the attendees were asked to introduce themselves and an attendance roster was circulated.

CRM REVIEW OF COATINGS DEFECTS RESEARCH

Mr. Renaux reviewed recent CRM research on the origins of defects in GALFAN. A chart showing the possible origins from the cold rolled surface, surface preparation details and galvanizing details is shown as an attachment to these minutes. Bare spots and craters are defects which mainly have to do with the wettability of the coating. Their origins and solutions, from the recent survey of the licensees, is presented as the next attachment. Slides of micrographs of the crater defects were shown and it was observed that the craters consisted of an oxide in a bare steel area. Usually the oxide was found on one side of the crater. The craters had a iron and manganese peak and were possibly rich in manganese oxide. Other craters were found to contain inclusions, which were rich in silica and alumina and were thought to be entrained onto the coating as a results of perturbations during the wiping process. The particles were believed to come originally from the refractory brick of the ceramic pot.

A second class of defects was caused by entrapment of particles. A list of these defects which includes surface encrustations, edge build-up, gibbosity, and horseshoe defects is shown in the next enclosure along with a list of proposed origins and solutions. The next class of defects relate to the crystallization of the GALFAN alloy on the steel surface. The defects include fish bones, fine lines, groove defects and coating sags. A list of origins and proposed solutions to these defects is also shown in the following attachments. Another class of defects has to do with the wiping characteristics of the galvanizing process. Ripples, edge overcoating, and uncoated areas are the three defects shown in the next enclosure. Their origins and proposed solutions are also listed. Finally, defects due to methods of cooling and solidification are summarized in the final enclosure of this section. These include holes at grain boundaries, waves and grain boundary dents or shrinkage. Their origins and solutions are shown. Examples of the various defects were shown to the group in a series of slides.

DISCUSSION OF COATING DEFECTS, THEIR CAUSE AND SOLUTION, BY OPERATING PERSONNEL

Mr. Ewing of Weirton Steel chaired this session, with the assistance of Mr. Brinsky and Mr. Celestin of Weirton Steel. Mr. Ewing began by noting that craters and bare spots were the most frequently reported defect on GALFAN. Seven companies have reported their occurrence. He passed around samples containing this defect from the production of Weirton. Mr. Celestin listed the main cause which Weirton believed to result in bare spots and craters which was the cleanliness of the steel strip entering the galvanizing line. He also listed the solutions brought up by the group which included reducing the dewpoint, increasing the activity of the furnace gas, prolonging the seasoning time of the strip, lowering the line speed, increasing the annealing temperature, and increasing the strip temperature. Mr. MacKinnon asked what percentage of hydrogen Weirton Steel used in their GALFAN line. Mr. Ewing replied that several compositions had been tried but that they had finally settled on 20 percent. Mr. Ewing also noted that Weirton had not seen bare spots since their first run. As shown on the summary, he believed that the cleanliness of the strip was the most important solution. They do electrolytic cleaning offline before galvanizing their strip. A scrubber brush system, which is driven in the opposite direction of the strip, is also used. Mr. Jones asked if the level of mischmetal could be one of the things to consider here because Inland Steel found in their early work many bare spots which had been solved through the CRM research by adding mischmetal to the zinc-5% aluminum alloy. Mr. Ewing agreed that low mischmetal levels may cause bare spots. Dr. Goodwin stated that Nisshin Steel had done work on the amount of bare spots in zinc-5% aluminum alloys with and without mischmetal which have been reported at a previous licensees meeting. Mr. Hirose noted that they do not now have a problem with bare spots because the proper levels of mischmetal were being held and that they had improved their furnace to lower the dewpoint and increase the hydrogen content. Mr. MacKinnon noted that in their production of normal galvanized steel, they sometimes had to use up to 50% hydrogen to eliminate bare spots.

Mr. Hoboh of Sumitomo Steel showed his sample which contained pinhole defects. He noted that in producing Grade E (full hard) panel, they had problems of craters and bare spots. However, in processes where annealing was required, they had no problem. Mr. Kato of Kawasaki also showed his material which contained craters and bare spots. He noted that they used a non-oxidizing furnace at Kawasaki without electrolytic cleaning. Dr. Coutsouradis noted that the effect of dewpoint, mischmetal level and cleaning all seem understood. The purpose of precleaning the strip is to remove something from the strip and he asked what the real origin of this might be. Mr. Ewing replied that their five stand cold rolling mill has a dirty rolling oil which cannot be removed in the cleaning section of the galvanizing furnace. Because it cannot be burned off, it needs to be removed by electrolytic cleaning. Mr. Jones related British Steel's experience, which is similar to this, which was that when they try to make a galvanized coating on a preannealed coil, bare spots are seen because of carbonaceous material which is baked on during the batch annealing process. Cleanliness is very important here. Mr. MacKinnon noted that at Stelco they saw similar problems. Even a direct fired non-oxidizing furnace cannot remove such deposits.

Mr. Farge asked how much mischmetal was contained in the Weirton coatings. Mr. Brinsky replied that they hold between .04 and .06 percent. They do not adjust the bath level of mischmetal but get it as is from their alloy supplier. Once they do get the pot stirred and mixed, he noted that the mischmetal level stays relatively constant and that they do not have problems in the level from that point. Mr. Polard asked if Weirton Steel sees differences on the strip from top to bottom (ie. from front side to back side as the strip emerges from the pot). Mr. Ewing said they do see such a difference and that the top of the strip (ie. the side not contacting the sink roll) is of better quality. Mr. Polard also asked if they saw an effect of degreasing on drossing. Mr. Ewing replied that they saw no relationship between dross levels and the amount of degreasing. Mr. Dewitte asked what the analysis of the top dross at Weirton was. Mr. Brinsky replied that it was a mixture of mischmetal, aluminum and iron at levels higher than those found in the overall bath.

Mr. Ewing then went on to the second most frequently report defect, which was waves and ripples. Six companies had reported this defect. According to many of the licensees' responses in the questionnaire, it was caused by too smooth of a steel surface. Factors such as air knife design and too high of a bath temperature also were listed. Solutions proposed were wiping with nitrogen, soft blow wiping and increasing the base metal roughness. Mr. Ewing reported that during the last run of Weirton Steel on GALFAN, one week before this meeting, they had run 800 tons of 0.057 inch thick steel sheet using different roughnesses. They had planned to look at the effect of this roughness on the elimination of waves and ripples. He also reported that it is very easy to get low coating weights with rough surfaces and they can get coating weights at levels of .9 oz/sq.^{2}ft. and under with no problems. Mr. MacKinnon asked if this was easy to do. Mr. Polard asked what the meaning of soft wiping was. He asked how soft it had to be. Mr. Hoboh of Sumitomo, who had listed the solution, replied that when they make normal galvanizing, their air knives are spaced off with a higher air pressure. When they make GALFAN, they can reduce the pressure, however, he did not know the exact value of pressure which made for the soft wiping. However, the soft wiping was found to improve the quality of these coatings regarding waves and ripples. Mr. MacKinnon asked if Sumitomo used stabilizer rolls to control the strip position as they brought the air knives in. Mr. Hoboh replied that Sumitomo had two driven stabilizer rolls. This enables them to very precisely control the strip position and have the knives quite close without too much variation in coating weight. Mr. Zwingmann asked what the temperature of the bath used at Weirton was to eliminate this problem. Mr. Ewing replied that the bath temperature was 900°F (482°C) and the strip temperature was 990°F (530° C). Mr. Zwingmann noted that the 0.057 inch (1.4 millimeter) gauge of steel used at Weirton had presented problems when made a Hoesch because too long of a residence time with strip resulted in an iron-aluminum-zinc layer. He asked if other companies had seen a growth of the intermetallic layer to the surface of GALFAN, which gives very low corrosion resistance. Mr. Ewing replied that they have not seen this problem at Weirton. Weirton cools its strip above the pot quite rapidly using an air system. They have a 45 foot high tower with a lot of air capaicty and a cooling rate of 45°F per second. Mr. Clark asked about the design of the air knives used at Weirton to get the quality stated. Mr. Ewing replied that their "half bow tie" design has a 3 inch long flat center with a .020 gap. This increases on the upper half out to .060 at the ends. They also have a "double bow tie" design, which has a gap of .020 inches at the center and increases on both top and bottom lips out to .080 inches at the ends. He also noted that dropping the pot temperature below that shown above had resulted in cracking of the coating from time to time. Mr. Jones asked what the knife pressure was and Mr. Ewing replied that it was 3-4 lbs/sq.in. gauge. Mr. Clark asked what the spacing of the knives was and Mr. Ewing replied that it was 3 inches from the knife to the strip. Mr. Clark asked if Weirton had experimented with reducing the air knife gap and the reducing the pressure concurrently. Mr. Ewing replied that they had tried this but that it doesn't seem to work as well as the details which he had just given. Mr. MacKinnon asked if these details were changed when they moved from GALFAN to galvanized. Mr. Ewing replied that the wiping characteristics of GALFAN and galvanized were substantially different and that a whole new set of parameters is needed to control galvanized versus GALFAN coating weights with air knives. Mr. Hirose also stated that there was a difference as previously given in one of his research reports.

The coating defect reported third most frequently, Mr. Ewing said, was grain boundary dents. He asked those companies reporting this to show samples of defective material. Mr. Hoboh showed the sample of Sumitomo which is produced using a water spray cooling. The defects are not so serious for applications which are unpainted, he noted, but Sumitomo plans to paint all of their GALFAN and the dent problem is very serious for that application. They need to overcome this problem. Mr. Clark asked what gauge and linespeed were used to make this material. Mr. Hoboh stated that the gauge was between .3 and .35 millimeters and that the line speed was between 90 and 100 m/min. Mr. Zwingmann noted that Hoesch cannot get rid of grain boundary dents even with high skin pass reductions. The grain boundary dent varies with aluminum composition and Hoesch has found that arange of 4.7% to 4.8% aluminum worked very well. Mr. Fuchs noted that he had examined grain boundary dent areas in their production and found that shallower dents had been found at the lower aluminum levels of 4.7 to 4.8 percent. Higher levels were found around 5.2 to 5.3 percent. He noted the occurrence of primary zinc phase in the grain boundary area. Mr. Hoboh disagreed with this observation and noted that using a microprobe, he had seen no aluminum or zinc segregation in the dented areas. They had used 4.7% also. Mr. Hirose asked if the 4.7% aluminum composition had given a material with a good enough smoothness for painting and Mr. Hoboh replied that their experience had been that this was not sufficient. Mr. Hirose stated that this had been the experience of Nisshin also. Mr. Hirose stated that this had been the experience of Nisshin also. Mr. Furken asked what the aluminum percentage in the GALFAN sample being passed around was. Mr. Hoboh replied that it was five percent (5%). Mr. Clark asked what the cooling rate was on the sample of Sumitomo and Mr. Hoboh replied that it was between 10 and 20°C per second. Mr. Hoboh added that Sumitomo saw the dent problem even with a "minimized spangle". However, Sumitomo does not really have full minimizing on their line. The incoming strip temperature for this material was 500°C and the 932°F 878° bath temperature was 470°C. Mr. MacKinnon asked if the bright rolling of cold rolled strip by Hoesch helped eliminate the grain boundary dent. Mr. Zwingmann replied that this does not help the problem.

Mr. Ewing reported that two companies had replied to the questionnaire about the defects of sagging and edge overcoat. Solutions proposed to this by the group were changing the wiping nozzle profile and its height. Dr. Hirose supplied samples to Mr. Ewing which had this defect. He noted that for heavy gauge GALFAN, it is particularly a problem because of the lower line speed, typically less than 20 m/min. A heavy sag is noticed on the coating on one side only. The other side appears to be alright. Nisshin is trying to improve their operating conditions. Nisshin defines their heavy gauge material as having between 1.6 and 6.0 millimeters in thickness. Their maximum strip temperature is 500°C with a minimum of 470 and a typical temperature of 480°C. Coating weight put on steel of this gauge range is 250 g/m^2. Dr. Coutsouradis reported the previous experience they had with wire galvanizing which was that sag defects are prevented by wiping with nitrogen. Dr. Hirose also felt that lowering the aluminum content to around 4.2% would also reduce sagging.

One company had reported the incidents of fishbone defects, according to Mr. Ewing. Dr. Pelerin stated that his company had found that these were a transitory defect which tended to go away after a while. Dr. Coutsouradis believed that this was caused by a solid dross being trapped under a liquid film of GALFAN as it created the coating on the strip. The dross would then be pushed upward by the air knives. Dr. Coutsouradis believed the problem could be avoided by avoiding the upward flow of air from the air knives. It should be directed more perpendicularly or even downward with respect to the strip. Dr. Coutsouradis noted that residual dross is something which occurs at the beginning of a campaign and that it was a reasonable explanation for the fishbone phenomenon. Mr. MacKinnon asked if Phenix Works pumped its GALFAN and galvanized pots. Mr. Polard replied that yes they pump the GALFAN into a cast iron pot and get bottom drosses. Mr. MacKinnon anticipated the same problems on their line. Mr. Zwingmann noted that Hoesch tends to pump down to extremely low levels in the working pot and that they do not have dross because they run at less than 0.2% aluminum. Dr. Pelerin noted that this problem will occur with any galvanizing alloy but that GALFAN seemed more sensitive to it.

One company reported the incidents of black patina. Mr. Kato of Kawasaki showed a sample which showed this problem. It had been chemically treated and he noted that the darkening seen always occurred after several months of exposure. Mr. Celestin asked if Kawasaki had seen differences in the black patina with chromated and non-chromated GALFAN samples. Mr. Hirose replied that without chromating, GALFAN is not as sensitive to patina as chromated GALFAN. Mr. Stoneman asked if darkening was worse in separate environments. Mr. Hirose replied that the high temperature high humidity environments tend to be worse for the black patina formation. Dr. Coutsouradis noted that they saw the worse patina formation in the high humidity industrial environments. Dr. Hirose noted that he had not seen that much sensitivity of the black patina to high humidity and that they were now running samples at between 60% and 65% relative humidity.

Mr. Ewing reported that one company had replied that the gibbosity was a problem, which is related to dross entrapment. Mr. Hirose noted that he believed that this was related to the mischmetal content of the bath. Mr. Clark had observed samples of GALFAN sent to him where pimples or lumps were found on the surface of the GALFAN coating. In these, he had found a mischmetal zinc intermetallic in lumps where the analysis of mischmetal was found to be 0.03%. He recommended reducing the mischmetal content to avoid this intermetallic phase. He also stated that it seemed to be more of a problem with induction stirred pots.

Mr. Ewing reported that the horseshoe defects, a grain shape defect, on the GALFAN coating was seen as a problem by one company. Mr. Hoboh of Sumitomo noted that he had seen this defect with a pot temperature of 470°C, a strip temperature of 500°C, and a strip thickness of 2.0 millimeters. Mr. MacKinnon stated that he had seen a similar problem with aluminum greater than 0.2% with normal galvanized. With aluminum under 1.8%, this problem does not occur with full hard grade steel. He also believed it may caused by aluminum additions which are undissolved after a time in the pot. His experience was that they always seem to be related to aluminum additions. Mr. O'Donnell noted that Stelco has made experiments in line and has always been able to correlate this defect with aluminum additions. Mr. Coutsouradis noted that in CRM's work they had seen dross trapped at part of the defect which may also be related to the aluminum addition problem. Mr. Hirose reported that he had also seen this problem and suspected that it was related to intermetallics which were present on the surface of the bath. Mr. MacKinnon asked what the size of the Sumitomo pot was that had shown this problem. Mr. Hoboh noted that it was 80 tons capacity. Mr. MacKinnon noted that on their largest pot, 185 tons, they had not seen this problem. However, with their 80 ton pot, they see more of the problem in normal galvanizing.

The defect of grain boundary cracking had been supported by one company. Dr. Warnecke noted that they had seen this problem with their run several years ago on coils that were rapidly cooled. Cracking was found upon bending these panels. Mr. Brinsky noted that Weirton had seen cracking on the grain boundaries during its first GALFAN run. This was they had lower pot temperatures. Now that they keep their pot temperature up, there are no problems with the grain boundaries cracking at Weirton. He stated that it was due to a low strip entry temperature and a pot temperature of 440°C or lower. 824 Dr. Goodwin asked if there had been any problem seen with the Zinquench here where the pot temperature is between 410-420°C. Mr. Buscarlet noted that they had not yet seen any problem. 770-788

Mr. Ewing reported that one company had seen the defect on lines on the GALFAN coating. He believed that this was caused by strip quality and the rest of the group agreed with him. Another defect reported by one company was crystallization defects. Mr. Buscarlet noted that this was a common problem which had been solved by improving their cooling system.

In a general discussion of the coating defects, Mr. Hirose asked if the filtering of the bath was commonly used or not. Mr. MacKinnon stated that it was not commonly used, however, he had seen literature on it directed to the steel industry for galvanizing bath. Dr. Goodwin stated that Metaullics is the U.S. manufacturer of such equipment and has adapted it for use in galvanizing lines. Mr. Ewing noted that Weirton Steel is planning trials on this system on their galvanizing line. Mr. Mathews noted that Nippon Steel does not use mischmetal in their zinc 5% aluminum alloy and asked if they have problems similar to those defects reported here. He asked if we can an answer on that from the Japanese producers. There being no further discussion on this point, the defects section was concluded. Mr. Ewing continued the discussion by addressing the subjects of coating control, wiping and cooling. Mr. Lait stated that nobody has reported that Heurtey minimizing process with GALFAN and he asked why this was so. Mr. Buscarlet stated that they do not use the Heurtey device anymore but have used it in the first campaign for GALFAN. They believe that it is effective for GALFAN. Mr. Celestin stated that many companies produce GALFAN with a wide range of surface quality regarding grain size and other features and asked if anybody produced GALFAN to a surface standard. No producer in the group replied that they had surface standards for their GALFAN product.

In the area of pretreatments of the strip for the galvanizing pot, there was no further discussion in addition to that held in relationships to defects earlier. In the pot composition, Mr. Clark asked if anybody had looked at additions to the pot to minimize spangle. Dr. Coutsouradis replied that in the laboratory, they have shown that zirconium and titanium additions minimize the GALFANspangle,atleastfrom a visualpoint.Mr.Buscarletnotedthat zirconium had been tried in a Ziegler production run during 1984. He showed a sample of this material which he said had an increase coating roughness and increased grain boundary dents compared to their normal GALFAN. He reported that their zirconium level here was .020%, which was a very low recovery compared to what they had initially put into the pot. Mr. Clark asked how much chromium was found on the surface of GALFAN after normal treatments. Mr. Brinsky replied that 3 to 5 micrograms/sq.in. of chromium was found after their treatment. They used the oakite F1 at Weirton. Dr. Coutsouradis reported that the typical chromate levels seen in their investigations are 10 to 25 milligrams/sq.m.

Mr. Ewing asked if there were any questions about skin-passing operations. Mr. Furke noted that they see more pick-up on their skin-passing roll with higher aluminum compositions, around 5.3 percent. Mr. Ewing noted that they do not see this problem with the composition that they use. They run their skin pass mill offline and use it dry. Mr. Furke noted that Hoesch runs its skin pass mill in line. Mr. MacKinnon noted that the Hoesch line had Scotchbrite treatment pads on it and asked if this was any help in eliminating the problem reported by Mr. Furke. No help was seen by this treatment as far as the high GALFAN aluminum compositions were concerned.

HOESCH INVESTIGATION OF GALFAN MICROSTRUCTURE

Dr. Fuchs stated that his investigation in the GALFAN microstructure has recently been concerned with determining the actual eutectic point of the GALFAN alloy. He was familiar with the deep grain boundary difference which were seen in the eutectic alloy and noted that at the 5% composition, primary phases of zinc were seen. He used the electron microprobe analysis on the GALFAN coating surface to determine its crystallographic topography. A surface area of 80 x 80 microns was examined. He noted that it was very difficult to get the composition of the eutectic phase because it is very fine. His examinations of structures went from an aluminum content of 4.8% up 5.3% aluminum. With all compositions, he used cooling rates of both 3°C and 50°C. With an aluminum content of 4.9%, there was a lower amount of alpha phase than in the other structures, but even at 1,000°C/second cooling rate, fine particles of alpha were seen. At 6% aluminum composition, he saw dendritic beta particles surrounded by dendritic second phase. From examining the 6% aluminum coating further, he concluded that the nucleation of the aluminum-rich beta phase is very difficult and actually the coating must be undercooled before solidification begins. He noted that the expected microstructures were not found because of the presence of primary phase and all compositions. This indicated that some non-equilibrium solidification was occurring. For each overall composition, Dr. Fuchs had prepared a plot of the composition versus the quantity of phase found for that composition. In each histogram, the alpha phase was always dominant, that is there was a peak in the histogram at a composition near that of pure zinc. Depending upon how much aluminum was in the overall coating, the population of other phases was found to vary. The overall eutectic composition was measured together. It was found that the maximum population of eutectic occurred at 5.3 percent. At an overall composition of 6%, twin peaks of zinc-rich alpha phase and aluminum-rich beta phase occurred with a lower amount of eutectic phase between these two peaks. However, in all cases, there was a significant amount of alpha phase, more than one would normally expect. This indicates that it nucleates very easily.

Dr. Fuchs had also studied the phenomena of grain boundary dents, and noted in the series of micrographs which he showed that there was a strong relationship between the presence of primary phase and the presence of grain boundary dents, as long as the alloy was hypoeutectic. The clustering of primary phase at the grain boundary dents was independent of the aluminum content of the bath within this range. He noted that the clustering of primary phase on the grain boundary dents went away when the composition went away from the high alpha eutectic zone. Yet to be determined is the effect of other phases on the grain boundary dents.

Dr. Goodwin asked the licensees if any of them had studied Superzinc regarding the grain boundary dent and if they showed the same boundary problems as GALFAN in this regard. Dr. Hirose replied that Superzinc had some grain boundary dents but not as deep as GALFAN's. He disputed the finding that there is a clustering of zinc-rich phase on the grain boundary dent, as he had not seen this before. He noted that the natural pattern of solidification would be from the interior of the grain to its exterior and, therefore, the primary zinc phase should be in the grain interior. Dr. Fuchs acknowledged this but stated that he has always stated observed the phase distribution to be in the way that he described.

HOESCH PRODUCTION REPORT

Mr. Zwingmann reported on the 1986 production activity of Hoesch. A copy of his report is attached to these minutes. Of the total of 56 hours for the pot change, he noted that 40 hours are required to convert the galvanizing line to GALFAN and tend to convert the line from GALFAN back to galvanizing. The ingot composition variations shown are for a 2-ton ingot, which is the standard used at Hoesch. He noted the variation in aluminum, cerium and lanthanum. Regarding the grain boundary dents, which are reported, these are about 5 microns deep in the work that they have done. Mr. Polard asked what sort of cooling was used for the coatings that were shown in the Hoesch work. Mr. Zwingmann replied that they do have a Heurtey device on the Eichen line, however, slow cooling is used for the GALFAN which is produced, without the Heurtey rigg. Mr. Mathews asked if the composition of the ingots varied when they pumped the pots repeatedly. Mr. Zwingmann noted that fresh ingot were used to fill the pot initially and that old ingots were used from time to time to make up the pot during each production run.

PRODUCTION REPORT FROM SUMITOMO

Mr. Hoboh presented his report, which are attached to these minutes. He noted that Sumitomo had recently revamped its existing line and gave the details which are shown in his paper. Regarding the operation of converting the line from galvanized to GALFAN, the biggest delay was the time needed to reduce the dewpoint inside the snout. The terminology "SS" used in the pot hardware experiments refers to commercial hot rolled steel. The other two materials used were 304 or 316 stainless steels. The pot hardware was all changed according to the chart. Sumitomo has done three actual trials with GALFAN with the last one being on November 9 and 10, 1986. Mr. Hoboh promised to have information available on this run on the following day. During the first two trials, the biggest problem was taking care of ripple, defects, and grain boundary dent defects. These had been discussed previously in this meeting.

KAWATETSU PRODUCTION REPORT

Mr. Kato presented his report on improved productivity by improving the bath exchange process between galvanized and GALFAN. A copy of his report is attached to these minutes.

Mr. Polard asked what type of heating was used on the Kawatetsu standby pots. Mr. Kato replied that these were electrically heated in both cases and that they were both made out of pure iron. There is a ceramic lining on the GALFAN bath. Mr. Sokolowski asked if Kawatetsu mixes GALFAN alloy into the pot during the campaign. Mr. Kato replied that they do not do this but only mix it in by pumping during the beginning. Mr. Polard asked if Kawatetsu completely empties their Ajax pot. Mr. Kato replied that it is nearly empty as it is pumped down to 2 tons. Dr. Goodwin asked if the inductors were full of metal or were emptied out along with the pot. Mr. Kato replied that 800 kilograms of metal remains inside each inductor and 400 kilograms in the heel of the pot.

Mr. Piesson asked Mr. Hoboh how he had measured his weight loss results in the salt spray tests, which he had reported. Mr. Hoboh replied that he had used chromic acid. Mr. Clark asked if the power to the inductors at Kawatetsu was on or off during the bath exchange. Mr. Kato replied that they were kept at a power of 100 kilowatts, just enough to keep molten and metal in the inductor channels. Mr. MacKinnon asked about the blastgate arrangement shown by Kawatetsu. He asked how they seal off the snout from the bottom. Mr. Kato noted that sealing is done by injecting nitrogen gas in between the two dampers of the blast gate. This keep the positive pressure, acting as a shield. Mr. Zwingmann asked about the ceramic lining for the pure iron GALFAN bath. He wanted to know what the thickness of the coating was. Mr. Kato replied that it was between 2 and 3 millimeters thick. Dr. Coutsouradis asked how the ceramic coating was applied on this standby pot. Mr. Kato replied that it was put on by spraying. Mr. Hoboh asked what the start of dewpoint was in the Kawatetsu line after the bath exchange described. Mr. Kato replied that it was -40°C. Dr. Goodwin asked how many metric tons were made in the third Sumitomo trial, which occurred very recently. Mr. Hoboh replied that it was 700 tons.

MINUTES OF THE NINTH GALFAN LICENSEES MEETING RESEARCH SESSION

Held At

The Crest Hotel
Siegen, West Germany

On

November 12-13, 1986

REPORT ON CRM RESEARCH

Dr. Davin reported on the CRM research program including results from the atmospheric corrosion tests, soil burial corrosion, undervehicles tests, gray patina, spot welding and lubricant testing. Dr. Davin began by giving a history of the atmospheric exposure programs at CRM. A list of the atmospheric exposure programs are shown in his report attached to these minutes. Dr. Davin showed slides of the 5-year exposure specimens. These were quite small and, therefore, the weight losses from them are not very meaningful. However, the sacrificial protection and the darkening on the various samples can be seen. Darkening of the GALFAN samples were quite severe in the industrial and rural environments. The performance of GALFAN samples of different coating thicknesses after 5-years exposure were shown. All samples are still in relatively good condition. This work will be further explained in CRM Progress Report #16. Effective chromating on long-term exposure compared to unchromated Galvalume and chromated galvanized was also shown. The results from these are shown in CRM progress report #15. Microstructures of the various coatings and various environments were shown. GALFAN in all of these samples appeared to corrode uniformly, whereas Galvalume showed pitting corrosion which disguised the natural weight loss. Also, the corrosion products on the Galvalume samples were not soluble, which tend to make the weight loss less than the amount of coating which had corroded.

The performance of GALFAN in plain soil and soil along a roadway in Belgium which received the icing salt, had been determined for 1 and 3 years. Panels of Galvalume, aluminized, GALFAN and normal galvanized had been exposed, both chromated and non-chromated. The coating weights of the samples and their origin are shown in a paper attached to this report. The clay soil is an alumina silicate earth, from a rural environment. Slides were shown of the samples after 3-years exposure. Poor cathodic protection was seen on the aluminum-rich coating. In the clay soil in particular, heavy edge problems were seen on the aluminum-rich samples. In this environment, GALFAN gets a bluish color, whereas the galvanized turns a dark gray. Specimens were cut from the slides for analysis but have not yet been completed for reporting.

Mr. Davin reported on the painted and unpainted panels of various substrates which had been placed under buses in Liege for up to 4 years. GALFAN panels had been part of this project with coating thicknesses from 5 to 15 microns. A complete list of the samples used is shown in an attachment to these minutes. One very interesting result of the project was that GALFAN panels with both the

17 and 15 micron coating thickness behaved the same after both 1 and 2 years. Regarding cut edge, GALFAN behaved better than Galvalume with the galvanneal panels performing next best after the GALFAN and Galvalume panels. On the nickel-zinc electroplate coatings, there was a problem with paint adherence and small blisters occurred. Painted hot-dip galvanized and electrocoated zinc panels showed larger blisters than nickel-zinc electroplated panels. The Zincrometal panels showed good paint adherence. However, in areas where the stones from the road had chipped the panels, red rust was found to occur.

CRM has continued it work on gray patina prevention using different post treatments which have been made available. The program consists of atmospheric exposure in Liege, Belgium and measuring light reflectance on these panels twice a month. The panels have been treated with an electrolytic nickel coating, the "Brugal" Procoat solution and a physical vapor deposition coating of chromium with 1-micron thickness. Panels from Hoesch were used for substrates. The best results were found with the brugal coating which showed 90% reflectance after both 2 and 4 months. The results from this work are shown in the attachment to these minutes. Also shown is a graph of reflectance versus time which shows that the chromated samples are eventually brighter after industrial exposure than non-chromated samples. The chromated samples actually increase brightness with time.

In the area of spot welding, 8-micron thick GALFAN coatings have been obtained from Kawasaki on a 1-millimeter sheet. A dispersion-strengthened copper alumina electrode was used with a 5-millimeter tip diameter. Other process variables are shown in a attachment to these minutes. Twenty-seven hundred (2,700) spot welds were obtained before the quality of weld became unsatisfactory. It is hope that these results will be far more acceptable to automakers and those previously obtained with the pimple electrode.

Finally, slides were shown of samples which had been used to determine the lubricant properties of GALFAN. These should be useful for drawing and stamping operations. The test procedure used for this work was one developed at CRM for the study of friction coefficients of alloys and the behavior of lubricants, called the ring test. Using this test, batch galvanized coatings were found to spall after the test, whereas GALFAN had no spalling. Ungalvanized steel had the same properties of GALFAN, which were superior to batch galvanizing. However, the GALFAN coating was much thinner than the batch galvanized results. The tests will be repeated with coatings of the same weight.

Mr. Lait noted the variability of corrosion results which had been seen with GALFAN in the presentation. Mr. Coutsouradis replied that this is due to the effect of process variables on the corrosion rate of GALFAN, a variation with coating cooling rate, steel thickness, chromating and skin-pass is found. The same behavior has been found for Galvalume. It is not known whether the same sensitivity has been determined for galvanized, but it is expected that galvanized would have less sensitivity than GALFAN or Galvalume. Mr. Mathews noted that their evaluation of GALFAN panels had gone all the way back to the beginning when material had been made on the CRM pilot line. They had also noted differences in the corrosion behavior of panels produced from the early small lines and the later high-speed lines. He also noted that unsuitability of using a Galvalume coating with a 150 g/m^2 coating. This is only intended for use as a substrate for paint and not for unpainted exposure. Heavier coating weights should be used with Galvalume samples in future work when looking at behavior of unpainted material. Mr. Farge noted that the results on the anti-patina work using the Brugal coating looked very promising. He asked if this coating was ready for commercial development. Mr. Coutsouradis noted that more work was needed to understand the gray patina problem. From their experience, the gray patina formation also depends on processing of the coating. For instance, nitrogen cooling appears to help as does rapid cooling. Using these techniques, gray patina can be considerably delayed. It may be possible to find a more effective way of preventing gray patina using this approach, however, the results with the Brugal coating look very promising. Mr. Hoboh noted that Ziegler had used nitrogen wiping with their GALFAN product and asked if gray patina had been any problem for the customers. Mr. Buscarlet replied that gray patina is not a problem in the applications of their customers.

CRM PROCESS DEVELOPMENT RESEARCH

Mr. Renaux described the work which CRM had undertaken with Wheeling-Pittsburgh Steel Company developing a galvanizing process for strip using the Cook-Nortemann process. This work had been carried out on September 23-25, 1986. A copy of his presentation and a paper on the process is attached to these minutes.

Mr. MacKinnon asked if CRM had determined a time-temperature relationship for flux drying. Mr. Renaux noted that this had not been possible because the mini-line ran at a constant speed and the furnace was of constant length. Dr. Goodwin noted that they hope to derive this relationship during a later pilot line run in Quebec, Canada. A mini-line had been found for scaling up the Wheeling-Pittsburgh work further and companies interested in Cook-Nortemann processing were expected to join in the sponsorship of the GALFAN trial on this line.

BRITISH STEEL CORROSION REPORT

Mr. Jones have his report which is attached to these minutes. In addition to presenting the work in the report, Mr. Jones noted that Galvalume has been exposed at their Burry port site for nine years and is performing very well. They have an unpainted Galvalume panel in the 48 month set at this location and so far the GALFAN panes is performing as well as the Galvalume panel. They will be interested to see if GALFAN can do as well after nine years.

NISSHIN STEEL RESEARCH REPORT

Dr. Hirose presented the report which is attached to these minutes. He noted that previous work on this had been presented by him including most extensively that at the Seventh Licensees Meeting in Brussels. He recalled the Bethlehem Steel paper by Zoccola which plotted the percent of aluminum versus corrosion loss in microns after 5-year exposures at various outdoor sites in the U.S. He believed that one could not use accelerated test information to judge the performance of GALFAN but rather use long-term outdoor results. He noted that Zoccola work was on a rough scale from 0 to 75% aluminum and that he wished to look at the range of 4 to 7% aluminum. To these samples, he had added 0.1% magnesium. The paper describes his work, which has lead him to believe that there is very little performance difference between samples having between 4% and 7% aluminum. He, thus, asked the group to consider widening the specification to include this entire range.

Mr. Mathews asked if the ILZRO patent on GALFAN covered the entire range desired by Dr. Hirose. Dr. Goodwin replied that it did indeed. Dr. Fuchs noted that Hoesch has found aluminum-rich layers between the iron and the coating which is made up of the intermetallic. With the lower aluminum content, he feared that pure zinc would form on the surface of the coating giving a lower corrosion resistance than normal GALFAN. The range of the patent of ILZRO was thought by CRM to be between 3 and 15 percent. Dr. Goodwin asked if they would like to do as ASTM does with their specifications and ballot the range of composition among the licensees. Mr. Mathew said that this would not give a sense of rationality to the coating limits and it would appear to be not founded on scientific data but rather the preference of various producers which can be seen as arbitrary. Dr. Coutsouradis also agreed that this would not be a good idea and that the problem with the Nisshin material appeared to be the cooling problem rather than a problem of composition. Dr. Goodwin stated that CRM could look at a range of aluminum contents in the alloy on a much finer scale than Nisshin Steel had and without magnesium being added. He thought a range of 4.2 to 5.1% would be useful to see at what point the grain boundary problem became serious.

PLANS OF SEVERAL LICENSEES

Because several licensees had to depart early, they agreed to present their plan to the group for the coming year. Mr. Petsch reported on the planned activities of Salmax. They expect to make a short GALFAN production run during January or February of 1987. During this production run, their first, they expect to make between 1,500 and 2,000 tons of steel coated with GALFAN.

Mr. Polard of Phenix Works noted that they do not plan to produce GALFAN in 1987 as it is not as economic to produce as normal galvanized. He noted that Phenix has a long-term exposure program underway and that the results after two years had already been presented to this group. They need to wait one or two years more before they can make a final judgment about the product and begin marketing it as an improved product. This will justify the higher cost of running the galvanizing line.

Mr. Galliez of Maubeuge noted that they had made no GALFAN during 1986 and might make it towards the end of 1987. Without the quota system enforced for their company anymore, there is no need to find another coating to make. Also, the low price which they can get for GALFAN at the present time militates against their stopping the line to make this product. The price they are obtaining in most cases in no better than normal galvanized.

The meeting was adjourned for the evening and reconvened the next day at 9:30 a.m. Dr. Goodwin welcomed the newcomers to the meeting and asked all to introduce themselves to the group.

GALFAN PAINTABILITY REPORTS - NORTH AMERICA

Mr. Roberts reviewed the past paintability tests which had been set up in cooperation with ILZRO. A report on the paintability testing from the last year had been assembled and mailed to the licensees recently. He noted that a cooperative program had been set up with Amchem, Heatbath and Parker on pretreatments and with DuPont and PPG on paint systems. Heatbath and Parker have completed their accelerated test program and Heat Bath has done no further work since this time. The results were previously reported. Parker finished their work and recommended systems for GALFAN. No more work has been carried out since this point. The results for Parker are also included in a past paintability report. Outdoor panel testing has continued at DuPont, PPG and Amcham. Mr. Roberts said he would report on results today from Amcham and DuPont. The results from PPG are not yet available because the panels are still out on exposure, however, they will be available during the next week and a report on these will be presented to the licensees at a future date.

Mr. Roberts noted that Amchem had put out two reports on GALFAN paintability, the first during November 1984 and the second during October 1986. They had looked at four different systems for pretreating the panels including zinc phosphate, a no-rinse chromate, and an acidic chromate pretreatment which was recommended for Galvalume. Each of the panels received one of the four pretreatments and then one of six different paint systems from U.S. suppliers was put on the panels. The systems included epoxy and acrylic primers and polyester, plastisol and fluorocarbon topcoats. The names of the suppliers were kept confidential but each supplier will receive the results of testing on his paint system. Exposures took place in four different environments including a marine environment in Ocean City, New Jersey an acid rain condition with high sulfur dioxide levels in Louisville, Kentucky, a tropical marine site in south Miami, Florida, and a rural site in Ambler, Pennsylvania. Panels for these exposures were given Olsen cup tests, scribes and a 1/4" diameter punched hole. The examining and the rating of these panels is shown in the reports. The ASTM D164 rating system was used. Amchem's conclusions on this work are basically unchanged from their 1984 report. They found GALFAN comparable in quality to normal hot-dip galvanized panel. GALFAN seemed to have a slight edge with respect to paint adhesion. Hot-dip galvanizing, on the other hand, appeared to have a slight advantage in corrosion resistance. The recommendation for a GALFAN pretreatment was the Granodine 46S/W, a zinc phosphate pretreatment. Mr. Alfano asked why hot-dip galvanizing did better than GALFAN in corrosion resistance. Mr. Roberts replied that the corrosion in from the edge of the panel is what the investigator measured and that, in this case, it was found that hot-dip galvanized was better than GALFAN.

Mr. Roberts then went on to describe the DuPont work. Since the program has begun, DuPont has left the paint business, however, the original investigators are still with the company which is now under other ownership. They have been willing to continue the work on this program. Panels of GALFAN and electrogalvanized were painted on one side in this program. They were primed or unprimed. Two different paint systems, an acrylic or polyester, were used. They were then exposed in the high ultraviolet environment of Florida. The primed samples appeared to have little change from the initial condition. The unprimed panels showed edge creep, however, there were no other features on the face of the panels. On the back of the electrogalvanized panels, speckles of white rust were seen, whereas in GALFAN this feature was not seen. DuPont concluded that a primer is needed for good performance. Panels will be reexposed in order to obtain further conclusions.

Mr. Roberts reported on other work which ILZRO is doing which involves GALFAN exposure. One is a program at North Carolina State University, which involves a corrosion of panels in an animal waste environment. Panels exposed include cold rolled steel, GALFAN and hot-dip galvanized. They are being used in experiments to determine rates in wastes of swine, chicken and cattle. The rack location outside the chicken house was shown as well as a site near a cattle waste area. Panels were also exposed over a liquid waste lagoon and over the solid waste area and dipped in the solid waste. The first report on this program notes that after two weeks of exposure, all their steel had some red rust. However, none of the submerged samples showed signs of corrosion. The hot-dip galvanized samples showed white rust expect for those immersed in the waste. GALFAN performed much better than hot-dip galvanizing in this regard.

Mr. Roberts also noted that Ford Motor Company was expected to undertake automotive paint trials with GALFAN but have not yet begun. Panels have been received by Ford and formed into hemflage designs. These had then been painted with standard paints. They were waiting to install some new atmosphere control equipment. When this had been put in, they would undertake new tests and later put samples out on the Arizona proving ground.

PRESENTATION ON PROCOAT PRODUCTS

Mr. Rodellas gave this report which is summarized in sheets which are attached to these minutes. The film forming products, which they make, are a combination of organic films and passivation agents. The corrosion tests on products developed for GALFAN include salt spray which give results up to 600 hours before white rust on flat panels and outdoor exposure where no white rust has been found after 18 months. This is with the product containing hexavelent chromium. A darkening test was carried out with the chromate-free product both in a moderate humidity cabinet and in salt spray. The darkening was found to be very low for products exposed in the humidity cabinet up to 3,000 hours. The coating also has good salt spray resistance. Procoat has manufactured this process with the intention of it being used by the general coil coating industry. A process route for the products is also shown. The product can also be primed and topcoated. When product thus made is tested, it shows very low white rust and edge creep in both salt spray and cyclic salt spray and outdoor exposure tests. Another product which Procoat has developed is a phosphating paint. This can be used as a primer or as a single coat. The process routes for these two applications are shown in the attachment. Using this product, good salt spray results have been found. Also, some Kesternich tests have been done which are also shown in the attachment. Mr. Rodellas also revealed that Procoat has developed a new process to coat paint onto hot strip. It is a water-based paint with a high corrosion resistance. The finish which they have developed is not yet equivalent to the paints which can be put on in the normal coil coating process but he believed that it could be used for some of the coil coating applications. It can be used as a heavy coating up to 8 microns or as a very low thickness coating to use as a base for topcoats. He hoped to have more information available on this new product at the next Licensees Meeting.

Mr. Farge asked if the Procoat filmforming passivating agent described in this work was the same as reported in the CRM work earlier in this meeting. Mr. Rodellas affirmed that it was. Mr. Farge asked if the gray patina in the Procoat work was the same as that as that of the gray patina measured by CRM. Mr. Rodellas again affirmed that it was. Mr. Coutsouradis asked if Procoat had tested as-is GALFAN under the humidity tests which had been described the darkening results. Mr. Rodellas replied that they had tested untreated GALFAN and in this case, the samples completely darkened within 24 hours. Mr. Mathews asked what the cost of the filmforming passivation treatment was. Mr. Rodellas and Mr. Brugarolas noted that the treatment is more expensive than the normal hexamalic chromium treatment and actually is priced more as a coil coating treatment because it involves an organic film. It is between 10 and 20 times the cost of the chromating treatment.

ELECTROCOATING CONDUCTOR ROLL

Dr. Goodwin presented a report from Hostetler & Decker, a United States engineering company, on conductor rolls for electrogalvanizing, electrofluxing and electrolytic applications in general for continuous processing. A copy of this report is attached to these minutes.

MINUTES OF THE NINTH GALFAN LICENSEES MEETING MARKETING SESSION

Held At

The Crest Hotel
Siegen, West Germany

On

November 12-13, 1986

MARKETING SESSION

The marketing session immediately followed the technical meeting which was adjourned at 10:15 a.m. Frank Goodwin summarized the work presented during the technical meeting and noted that the quantitative work at CRM and the exposure work at British Steel demonstated the good corrosion resistance of GALFAN. He stated that work was continuing in the grey patina prevention, undervehicle corrosion examination, spot welding improvement and the atmosphere and soil corrosion testing of GALFAN. He then reviewed the major points from the operating session, particularly the various defects found on the products and the methods used to eliminate the defects. He stated that in order to market GALFAN well, the manufacturers need to produce consistently a high quality product.

REPORTS FROM THE REGIONAL MARKET DEVELOPMENT ASSOCIATIONS

Frank Goodwin invited the various representatives to present the GALFAN market status in their various regions.

EUROPEAN REPORT

Mr. Alan Stoneman of the Zinc Development Association presented an update on the marketing efforts for GALFAN in the U.K. Mr. Stoneman stated that the Zinc Development Association has taken the responsibility for informing the marketplace about the existence of GALFAN and for generating and sustaining interest in the product throughout the U.K. The first phase was to mail the recent brochure published by the European Zinc Institute to a list of about 600 companies and organizations. The list was compiled from the ZDA files and included general fabricators, roll formers, deep drawers and end users in the automobile, appliance and building industries. Also, brochures were mailed to specific organizations such as the coal and electricity industries, research organizations and educational establishments which have their own research facilities. The brochures were mailed at the beginning of October. Mr. Stoneman explained that the role of the EZI regarding GALFAN is to raise the funding required to operate as a central source for market development, and to coordinate the marketing strategy for Europe in conjunction with ILZRO. In effect, the European market development associations act within their own regions under the overall umbrella of the EZI. Mr. Stoneman further stated that the role of the Zinc Development Association was to introduce GALFAN to the market place with the use of the brochure, to supply further technical information when required, and to ensure prompt delivery of coated sheet and wire samples for forming and corrosion testing. The ZDA has, therefore, seen a steady daily increasing flow of inquiries on GALFAN. The most potentially important contacts have been in the building industry. This is one area where the use of GALFAN coated sheet could help to regain the market for zinc coated steel which has been lost to some extent to stainless steel in wall tie applications.

Frank Goodwin asked if there were any other reports from the U.K. Mr. Austin Mathews stated that British Steel had considered the possibilities of conducting a production trial during 1986, but they did not manage to schedule one. He continued by stating his views as a marketing person on the marketing relationship between GALFAN, galvanize and Galvalume and other competitive products. Mr. Mathews stated that the marketing group should focus on product differentiation combined with market segmentation. He noted by illustrations the property and marketing strengths of the three "G" products, namely Galvalume, for corrosion resistance (implying opportunities in metal building), GALFAN for formability (implying automotive and domestic applicance markets) and galvanize for areas where full sacrificial protection is required. He emphasized the the two major markets for GALFAN are automotive and domestic appliances and the greatest enemy in these markets is plastics. Mr. Mathews stated that less effort should be expended at displacing Galvalume or outperforming galvanize and more efforts directed towards identifying the market niche for which GALFAN is best suited and above all combatting the claims and market strides made by plastics.

Frank Goodwin asked if there were any other comments related to the U.K. market. In response Mr. Ian Robertson asked Mr. Stoneman if any samples have been sent out either through the ZDA or CRM. Mr. Stoneman replied that ZDA's sample bank had been established during the week of November 1. Several requests for samples had been fulfilled through CRM and various suppliers, and that ZDA should now be able to serve the U.K. market.

Frank Goodwin invited Mr. Raymond Sempels of the European Zinc Institute to present the European marketing report. Mr. Sempels stated that the Market Development Committee of the EZI had been authorized by its Board of Directors to lead and coordinate market development of GALFAN in Europe. A seminar was organized in 1984 to decide on the proper time to develop the market for GALFAN. It was decided that GALFAN was ready for promotion and the EZI should promote GALFAN to the galvanizers. At the 1985 Intergalva conference in Munich a first promotional meeting was arranged. Subsequently, an agreement was reached with regional market development associations where EZI would coordinate the promotional work for GALFAN. The Market Development Committee of the EZI returned to the Board of Directors with a report on the Munich meeting and the agreement made there. It was then decided that the EZI would move ahead with the promotion of GALFAN. There was a general concern that the development already underway for Galvalume would lose markets for zinc. GALFAN offered the opportnity for further development of zinc consumption in the automotive, appliance and some metal building markets. The first activity of the EZI was to publish the GALFAN brochure. A summary list of literature and technical papers was also compiled by the EZI. Mr. Sempels stated he appreciated the commitment ILZRO has made towards the publishing of a new GALFAN manual. Mr. Sempels stated that the EZI organization offered unified front for contact between producers markets and ILZRO, and the EZI would like to be active in regions such as Eastern Bloc countries where no marketing agent is available. Mr. Sempels concluded his report by stating that GALFAN marketing activities must continue and the EZI is committed to providing the funds to continue its development.

Mr. Austin Mathews stated that the suppliers and promoters must be careful about the quality of samples sent out to potential users for examination. The quality of the products from the various suppliers should be consistent and of top grade. He suggested that EZI and ZDA either send samples obtained from one supplier or obtain only the best samples that are available. This is to ensure the varying results will not be obtained by the examiner. He noted that Mr. Sempels did not mention the competition presented by the plastics industry and reemphasized that plastics were the predominant enemy for the GALFAN and zinc producers.

Mr. Sempels stated his concern with Mr. Mathews' statement that plastics were the strong competitor for GALFAN, noting the rapid growth of Galvalume capacity. In response to the comment on the quality of the samples supplied, Mr. Sempels stated that for reasons of quality control the EZI has asked CRM to provide the samples and to examine and control the quality of the material being distributed. EZI will continue to follow-up on what each examiner does with the samples provided, nameley, the various tests conducted and to remain informed on the results obtained. He noted that if large sample requests were received then EZI would direct the customer to the supplier. This would ensure a supply of materials with the proper specifications. He stated that EZI is very much concerned with the movement of the plastic industry and to the erosion of the zinc and steel markets. He said that the focus of the EZI is no longer just to present the product but also to find the market segments that are best for zinc, and expand the markets for zinc by way of GALFAN and galvanize.

Frank Goodwin asked Hoesch to present their paper on the development of GALFAN in the German market. A copy of their presentation is given below.

GALFAN Licensees Meeting

November 12, 13 and 14, 1986 — Crest Hotel Siegen

This report should give you an idea about the experience of the Hoesch-group on GALFAN.

For 1986, four GALFAN campaigns were planned, which were carried out at the following dates:

January	with about 3,000 t
April	with about 5,000 t
August	with about 3,500 t
October	with about 2,800 t

Also in 1987, we have to stick to production in campaigns and we will probably produce quarterly again. The next date has already been set for January 1987. The further dates are:

April
July
October

The major problem for marketing the product is the cycle of campaigns. These should be operated at shorter periods, but that would mean an additional investment. Customers who have a great variety of products can hardly change at present, because a sufficient stock holding from campaign to campaign is not possbible. Partial and additional requirements cannot be covered anyway.

A further handicap is that at the moment there are not sufficient suppliers in the market. Here, we recognize till now that Hoesch holds a leading position in marketing the product on the domestic-market, but that a lot of holder of other licenses are still in a waiting position.

Nevertheless, a number of customers have already modified their buying policy, for whom we run a stock. The following applications, among others, are concerned:

white products
blower housings for filters
profiles for the automotive
lamp holders for bulbs
electro boxes

In the automotive sector there are hardly any appliances yet. Only with VOLKSWAGEN, from September, the first quantity of 20 t/m seems to be realized for a certain enduse.

U.S.A.

At the beginning of this year, 200 t of GALFAN were supplied to a customer in the Gulf Region. As to our knowledge, the material found acceptance without any problems. We are trying to catch up here.

We have been negotiating with a lot of customers who showed interest. Samples have already been processed. However, in some cases we need the UL-approval, which should be finalized soon.

As for the rest and to our knowledge GALFAN has not yet become well known in the U.S.A. just as little as the SUPER-ZINC of the Japanese.

EUROPE

Also here GALFAN is not well known. The STEEL SERVICE CENTRES are little informed about this material. At present, no great interest has been found because there is no requirment from the end users.

Other Third Markets

There is hardly any demand from these markets. The marketing in this area is certainly much more difficult, as the product is almost unknown. Therefore, our aiming points should be at first the European market and the U.S.A.

GALFAN As Base Material for Plastic Coating

a) Domestic Market

At first, the above-mentioned concerning HOT-DIP GALVANIZED applies, the campaigns must be at shorter intervals and the preparation of the campaign must be improved.

b) Export Markets

We have a major European customer who accepts GALFAN as base-material. For 1987, with this customer we do see the possibility to achieve a volume of about 3,500 t/y. Generally, in export we see the greatest chances in the range of plastic coated products, in the range of trapezoidal profiles.

For the future, we see good chances for a further development of this product in the market, where it is important to get the approval on the admissions for ROOF and WALL.

Despite all these facts, very much work of advising and introduction will have to be done. Not only the sales departments are demanded, but also especially the customer service department and the quality control department.

HOESCH SIEGERLANDWERKE AG, Siegen

Mr. Sempels asked how Hoeasch positons GALFAN in relation to galvanized in selling and marketing it to the customers. Mr. Wolf replied that Hoesch pushes GALFAN for specific end uses depending on the customer. Also, many customers who use galvanized material regularly would like to test GALFAN.

Mr. MacKinnon asked if Hoesch quotes a premium price for GALFAN. The reply was negative.

Mr. Robertson noted that an approval was needed for the use of GALFAN in roof and wall applications. He asked how difficult it was to obtain the approval, and what other problems were being encountered with the standards that have to be adapted to include GALFAN. Mr. Robertson also asked if there was anything the zinc industry associations could do to assist in overcoming the various problems. Mr. Schwarz said that they do not have much difficulty with the standards. He noted that there was an association for building techniques in Berlin and an approval has already been made in Berlin for GALFAN for the building industry. Mr. Wold added that only UL approval is needed for the United States.

Mr. MacKinnon asked if Hoesch offers a gurantee for GALFAN in Germany. Mr. Wolf replied that a guarantee was not given for GALFAN.

Frank Goodwin introduced Mr. Rispoli of ICMI and invited him to present the marketing report for Italy.

Mr. Rispoli said that in 1987 ICMI would like to conduct a GALFAN trial. They have not yet produced any GALFAN to date. The company that has the license for Galvalume in Italy has not produced only Galvalume either and he suspects that they do not have the correct pot either.

Mr. Rispoli said that Italsider has produced about 20,000 tons in 1986. In Italy the problem for GALFAN, and probably also for Galvalume, is predominantly commercial and it involves the pricing of the product. The market does not want to pay more than the galvanized price for either GALFAN or Galvalume. The company that has the license for Galvalume is La Magona d'Italia.

Mr. Limare asked if the Lavagal material developed by CSM is similar to any of the other alloy coatings. Mr. Rispoli replied that Lavagal was similar to Galvalume.

Mr. Mathews stated there was a great demand in Europe for an awareness campaign on GALFAN and he was pleased that the GALFAN brochure has been published by EZI. He reiterated that there was a need to get a product entry and identity in the marketplace for GALFAN. He stated that if videos were made and presented to the various customers then that would go over strongly in addition to the brochures. Mr. Sempels stated that it was in the plan and 1987 budget of EZI to prepare a video based on the full set of slides to be provided by ILZRO. The EZI have approved the plan, in principle, to putthe video together. The budget for the full program has already been accepted. He noted that EZI received good response for the first brochure and they plan to publish a second one. The cost of everything is estimated at $100,000 in 1987.

Frank Goodwin stated that there has been a structual change in the GALFAN activities within the staff of ILZRO. A GALFAN Resource Center is expected to be established within the next few weeks. The Resource Center will have its own identity within ILZRO.

Mr. Mathews reemphasized that the video and brochures will not capture the audience unless the customers are invited to one location such as Berkeley Square in a seminar where they can meet the various producers of GALFAN and see the various products made from GALFAN sheet, wire and tube. He stated that it was not efficient or sufficient to continue to have one customer meet one producer representative.

NORTH AMERICAN REPORT

As there were no other comments on the European market, Frank Goodwin introduced Mr. Celestin of Weirton Steel and invited him to present the first of the North AMerican Marketing reports.

Mr. Celestin voiced his thanks to Mr. Mathews for the comments he made regarding the marketing of GALFAN. Mr. Celestin said he concurred with all of the comments made by Mr. Mathews. He also explained that when Weirton decided to go forward with GALFAN, they also looked at the 3G (GALFAN, Galvanized, Galvalume) concept that Mr. Matthews presented. Weirton decided that the best move for GALFAN was in certain specific markets. The choice of the market was not made on the basis of competing with galvanized or Galvalume, but on the basis of competing with the No. 1 competitor; plastic. He said that Weirton Steel had four production campaigns in 1986 and have produced over 4,000 tons of GALFAN. The material gauge were from 0.26 mm to 1.78 mm, with 710 mm to 1067 mm width and coating weights from 92 g/m^2 to 351 g/m^2. Weirton uses the pot-in-a-pot technology with a change-over time of 40 hours going in with GALFAN and 16 hours coming out. Mr. Celestin noted that the appliance market was the number one market for GALFAN in the U.S. The appliance market presents conditions of high humidity and corrosion. Other markets included the automotive, construction, and metal building markets. Mr. Celestin stated that a significant amount of work has already been conducted for the metal building market. Mr. Celestin noted that the term "market segmentation" as referenced by Mr. Mathews is called "niche marketing" at Weirton. Weirton has been conducting several investigations on bare and painted samples of GALFAN to determine potential niche markets for the product and the position of GALFAN in the marketplace. Weirton and their coil coaters have been using Parker Chemical products for various pretreatments for GALFAN products directed to the metal building industry. Mr. Celestin informed the group that Parker Chemical was bought out by Amchem. Tests at Parker have shown Bonderite 1303 pretreatment to be acceptable as a complex oxide pretreatment but is has not been as good as some of the other pretreatments that are available. Parker 37S, a zinc phosphate, has been working well but is not as good as the newer pretreatments. The Bonderite 1310 has been ruled out and is not recommended for GALFAN. A pretreatment that works well is the new dry-in-place chromate Bonderite 1415A. The one that is best is the new zinc phosphate pretreatment Bonderite 1421. This pretreatment has been working well in all of the laboratory evaluations. A coil coating run will be conducted within the week on coil coating lines in the U.S. using the new B1421 pretreatment. For chromating, the JME reactive chromate is used. The best primer is the epoxy primer. Good topcoats are polyester and silicon polyester, however, the better topcoats have been the plastisols and fluorocarbons. In the appliance market, most painting in the past was done after fabrication. A lot of development is now directed to the coil coating or prepainted applications for the appliance market.

Mr. Celestin stated that the appliance coil coated market would be an excellent area for GALFAN to move into. GALFAN and galvanize behave similarly as far as spot welding is concerned but Galvalume is not a good product for welding. One way to overcome these spot welding problems is to focus attention to the application of adhesive bonding and another is using lighter coating weights. Adhesive bonding is not only considered for the appliance market but also for the automotive market to replace spot welding. However, a lot of development is needed and some are underway in several laboratories. Weirton is working with adhesives companies to develop information for GALFAN on this. One advantage realized with spotwelding of GALFAN is a reduction of corrosion at the weld. Mr. Celestin stated that Weirton has conducted tests involving the use of wire metallizing (85% Zn-15% Al) and metallizing over welded areas. This process puts the corrosion protection back onto the weld area. The product has been painted and placed in several test environments. Weirton has conducted several tests including Kesternich and cyclic testing to compare the performance of unpainted GALFAN with unpainted galvanize and Galvalume. A cyclic test was used which consisted of a two ppm SO_2 atmosphere. The GALFAN was exposed to the SO_2 atmosphere under wet conditions for 8 hours then dried for 16 hours. The cyclic conditions were much more severe than the Kesternich test of constant wetting.

GALFAN and galvanized coatings were tested with weights of 275 g/m^2, and Galvalume with 185 g/m^2. The results of the Kesternich test showed that start of red rust occurring on G90 galvanized after 10 cycles and complete red rust failure at 15 cycles. On the GF90 GALFAN, however, no red rust was observed at 15 cycles. For Galvalume, the onset of red rust was observed at 15 cycles. After 20 cycles, traces of red rust was observed on GALFAN. The appearnace of the Galvalume remained the same as it was at 15 cycles and the G90 galvanized samples showed very heavy red rusting after 20 cycles. The total failure for GALFAN occurred at 23 cycles whereas the Galvalume remained O.K. after 25 cycles.

Other tests at Weirton include water immersion testing. The tests are presently underway but no results can yet be reported. Weirton have also supplied GALFAN samples to underwriters Laboratories for testing. A UL approval has now been given for GALFAN for parts requiring safety in the electrical equipment market. The UL test resuts showed that a GALFAN coating 185 g/m^2 is equal to or better than a galvanized coating of 275 g/m^2 andthat a 137 $g/^2$ GALFAN coating is equal to or better than a galvanized coating of 185 g/m^2. The lighter coating of GALFAN can be used in the United STates in areas that normally require 275 g/m^2 galvanized. Further tests are underway at UL to compare GALFAN coatings of 137 g/m^2 with galvanized coatings of 275 g/m^2. Mr. Celestin stated that a number of welding tests have also been conducted at Weirton and GALFAN is able to meet the welding requirements of the customers.

Mr. Celestin announced that the ASTM sheet specification is complete and is now going to the full committee for approval. A specification number is expected by next week. A final report on this work is expected in February.

Several samples of GALFAN have been placed on racks in several highly corrosive environments at Weirton and near the Ohio River at a sewage plant. Very quick results are obtained because of the high corrosivity of the environments. Weirton has not seen any evidence of grey patina on any of the GALFAN panels after several months of exposure. The only negative results they have had deal with welding. However, with new adaptive techniques, there is no problem in welding GALFAN.

The predominant markets for GALFAN are the appliance and automotive markets. In the automotive market the GALFAN product is directed towards unexposed body parts. Mr. Celestin showed the group a power door lock motor housing that was very deep drawn from GALFAN. The part will replace cold rolled cadmium clad steel and will consume 150 T/month. The coating weight of the GALFAN used to draw the part was 275 g/m^2. Mr. Celestin stated that Weirton is presently marketing GALFAN only in markets where GALFAN is considered the best material available. If a customer is satisfied with the performance of galvanized or Galvalume for a particular application, Weirton would not try to push GALFAN onto that customer. Major areas of dissatisfaction with current products are formability and paint adherence. However, if the customer is dissatisfied with the performance of the galvanized or Galvalume material, Weirton then would present GALFAN samples for trial in the particular application to see whether the GALFAN solves the problems.

Mr. Celestin pointed out that a warranty of 20 years and 6 months is offered to Galvalume customers. Weirton is offering a warranty to GALFAN customers on painted products, when the paint system is specified by brand. Pricing is improved this way.

Mr. Jones asked how the welding tip life of GALFAN compared with that of galvanized during the spot welding experiments. Mr. Celestin stated that the adaptive control experiments are still underway at another company and he does not have all the details. However, the results will soon be available and will be distributed.

As there were no further comments, Mr. Celestin concluded the Weirton report. He then announced that because Dr. Richard Lynch of the Zinc Institute was unable to attend the Licensees Meeting, he was asked to present the North American marketing report on the behalf of Dr. Lynch. Mr. Celestin noted that the markets that the Zinc Institute is focusing on are the appliance, automotive, fencing, lighting fixture and agriculture equipment markets. There are continued developments in the coil coating of GALFAN and the promotion of the improvements to customers. Dr. Lynch reports that there is now greater awareness of GALFAN in the United States and Canada compared to last year. The date file that has been produced by the Zinc Institute is out on the market and various papers and data sheets on the performance of GALFAN have been distributed throughout North America. The most recent papers were presented at the Canadian Institute of Metallurgy and the International Appliance Conference. Indiana Steel and Wire is a new licensee which expects to enter production soon. It is getting GALFAN wire from Europe to distribute to their customers. The GALFAN ingot specification is available and the number is B750. The wire specification is A856 and the wire strand specification is A855. The sheet specification is expected to be available shortly. Two new wire specifications for ACSR wire are also being completed. Dr. Lynch requested discussion on a procedure to standardize GALFAN according to the appearance of the product. There are differences in product appearance from producer to producer, which will lead to confusion among customers. Second sourcing can be very difficult because of this. Dr. Lynch would like to propose a more formal marketing session at the next Licensees Meeting to discuss in depth the end uses for GALFAN land examine why GALFAN was the right choice for the particular end uses. Mr. Celestin noted Dr. Lynch's announcment of the Cold Line Meeting in Montreal in December. He also noted that Wheeling Pittsburgh, Empire Detroit, H.H. Robertson, LTV, Stelco, and Gregory were all interested in the flux development, and will be attending the Montreal meeting to consider sponsoring the cold line trial. Mr. Celestin stated that U.S. Steel has a partial License for GALFAN and are presently evaluating the product, as is Inland Steel. He suspects that within the next few months another source of GALFAN will come on stream in the United States. Mr. Celestin then asked for questions from the attendees. As there were no questions, Mr. Celestin concluded the ZI report, stating that this market is very exciting, but highly segmented.

Mr. Alfano presented his report on developments at Stelco and stated that Stelco continues to evaluate GALFAN for its performance. Stelco was also examining the various production methods to determine their ability to produce the material. Stelco is presently thinking of producing GALFAN on their Cook Nortemann flux line and are examining the problems that may be involved in doing the problems that may be involved in doing so. As far as the marketplace and market segmenting is concerned, Stelco is considering GALFAN as an improved product for the coil coating industry. Regarding the development of new markets for GALFAN, Stelco thinks that the marketing efforts conducted by Weirton and Zinc Institute have been excellent, however, Stelco contends that GALFAN is still in the product development stage and much more product and market development work needs to be done. He said that the operators will have to work towards solving the various operating problems to insure product consistency in the performance of the product as many users will be examining products and samples from various producers. Mr. Alfano stated that care should be taken not to promote GALFAN too rapidly before the product is fully developed because this could lead to underdeveloped products being released into the marketplace. Stelco is still determining if GALFAN is really a superior product. Mr. Mathews noted that Stelco has already decided what segment of the market the GALFAN should be directed and are now looking at the quality of the product for the particular market. Mr. Mathews made it clear that the illustration that was drawn earlier referred to a position further back from that of an already determined market. That is, trying first to identify the market and then determining what the market should be for GALFAN.

JAPANESE REPORT

Since there were no further comments related to the North American market, Frank Goodwin asked that reports from the Japanese region be presented.

Dr. Hirose presented the marketing report from Nisshin Steel. He noted that there has been several production runs for GALFAN in Japan by several companies, namely Yodogawa, Nisshin, Kawasaki and Sumitomo. He said there are some movements in fixing standards for zinc-aluminum alloy coatings in Japan. The standards are not in place at this time but they are being considered. The products are Superzinc, GALFAN and other 5% Al-Zn coatings. Mr. Hirose then presented the Nisshin production and marketing report for GALFAN.

So far in 1986, Nisshin has produced 5,500 tons of GALFAN. In December 1986 Nisshin is expected to produce and additional 1,000 tons Nisshin is focusing on the housing market not for roofing and siding but for structural parts such as shaped channels. The steel thicknesses is usually heavy that is 1.2 - 4.5 mm with a possible maximum of 6.0 mm. For 1987 Nisshin is planning to produce GALFAN every two months. They anticipate a production of about 1,000 tons or more each run. In 1986 the production was for hot-rolled material. The next production run will be in April and the total production for 1987 is expected to be approximately 6,000-9,000 tons. However, this will vary according to the production of lighter gauge GALFAN. Dr. Hirose noted that there are no difficulties in applying organic coatings on GALFAN.

Mr. Stoneman asked Dr. Hirose what the attitude of the Japanese automobile industry were towards GALFAN. Dr. Hirose replied that the automotive producers in Japan are not as interested in the GALFAN product as the European and U.S. automakers. Mr. Mathews added that the Japanese automotive industry has made great claims on productivity and there are certain problems with GALFAN such as welding which the production process and standards in the Japanese industry would not be able to deal with. Mr. Mathews then asked that new techniques for welding GALFAN, such as laser welding, be considered. The technique could possibly be developed for welding GALFAN and other galvanized steel.

Mr. Hirose said that it was correct that GALFAN could not be used for the automotive body panels but there are certain areas under the body of the automobile where GALFAN could be used and should not present problems regarding welding. He noted that the Japanese automotive companies are more interested in the electrocoated and galvannealed steels.

Mr. MacKinnon asked about the feedback control systems for automatic control during welding of galvanized or GALFAN coated steel. Dr. Warnecke replied that Thyssen has not worked further on the automatic welding controls for GALFAN since the last GALFAN welding report was given.

Mr. Iwanuma stated that from January 1986 to August 1986, Kawatetsu Galvanizing had produced 8,200 tonnes of GALFAN. Later this year, they will make 2,300 tonnes, for a 1986 total of 11,000 tonnes. For 1987, they forecast production of 15,000 tonnes.

Mr. Hoboh said that Sumitomo has not yet fully decided on their production program for next year. However, for 1987 they hope to produce 6,000 tons of GALFAN.

NEW ZEALAND REPORT

Frank Goodwin asked if anyone could state what the level of GALFAN production was at Yodogawa. As there were no comments the regional reports continued with the report from New Zealand

Dr. Norman Clark presented the marketing report for GALFAN in New Zealand. He said that New Zealand is determining their production possibilities. The first production of GALFAN in New Zealand is expected in the middle of 1987 and will only be for 2 or 3 days. New Zealand Steel presently has approximately 4,000 tons of GALFAN product, acquired from other producers, under evaluation in the marketplace. Dr. Clark stated that the biggest problem has been the pricing of the Zincalume product from Australia. The alloy for Zincalume is 60% over galvanized whereas the GALFAN alloy price is 90% over galvanized. This represents a significant price reduction for Zincalume compared to GALFAN. This has added another complication to their plans regarding GALFAN production. Dr. Clark pointed out that New Zealand Steel would need to acquire a ceramic pot for their GALFAN production. He noted that no presentation were made on the soldering performance of GALFAN which was on important parameter for various applications in New Zealand.

Frank Goodwin asked if anyone could make a comment on the soldering of GALFAN. No comments were received.

Ian Robertson asked Dr. Clark if the prices he presented for the Zincalume and GALFAN alloys represented the same coating thicknesses. Dr. Clark said that they were for similar thicknesses.

Frank Goodwin asked if there were further comments about the status of the various markets. As there were no further comments on marketing the meeting continued with discussions on GALFAN standards.

STANDARDS

Mr. Celestin noted that Nippon Steel had requested that Superzinc be included in the GALFAN ASTM standard and asked if Superzinc and GALFAN be included in the same ASTM standard. Frank Goodwin stated that galvanized, GALFAN and Galvalume all have separate standards and that Superzinc should have its own standard also. Norm Clark stated that Zincalume and galvanized are both in the same standard in New Zealand. Dr. Clark also noted that if a standard for 5 percent aluminum was needed it would be included in the existing standard for hot-dip coatings. Mr. Celestin stated that there was one general standard for various types of coated steel that is being considered by the ASTM.

Frank Goodwin stated that he thinks it would be best to have separate standards for each of the coated products. Mr. Celestin concurred that the standards should be separate. Mr. Alfano stated that Stelco would like to see a standardization of the coating as it would help in the marketing of the GALFAN product. Frank Goodwin noted that the standards for Type I and Type II aluminized steels are directed towards different markets, in the U.S., therefore, the different standards seen in various regions for the various types of galvanized coatings are justified. The differences in the standards would not offer any confusion to the customers.

Frank Goodwin asked how the standards for aluminum coated steel are presented in Japan. Dr. Hirose noted that there are two specifications for aluminized steel in Japan, that is Type I and Type II. However, the details of the standards are quite different from those in the U.S. In the U.S. Type I is for aluminum-silicon alloy and Type II is for pure aluminum. In Japan, however, Type I and Type II do note refer to the coating composition but to the coating weight only. It does not matter whether pure aluminum or the alloy is used for the coating. Type I refers to thin coatings and Type II is for heavier coatings. After further discussion from the group, Frank Goodwin noted that it was recommended that separate standards be applied for GALFAN and the other coatings. He then asked for an update of the standard activities in Germany.

Mr. Schwarz stated that there are presently no activities for the standardization of GALFAN in Germany. Present activities are directed towards the development of a GALFAN brochure with DVV and not on standardization. In Europe there is a new organization on standardization and together with the European Community and EFTA a proposal has been developed to standardize GALFAN and Galvalume and probably also Lavagal. However, Mr. Schwarz does not think anything will develop quickly as the standarization committee completes one standard every two years.

Frank Goodwin asked if there were standardizing activities in other regions. Mr. Mathews stated that he was not familiar with any activities in the U.K. Mr. Stoneman stated that there are no activities to report on regarding the standardization of GALFAN in the U.K.

Frank Goodwin reviewed the production figures for the various regions. He stated that Sumitomo reported a 1987 production of 6,000 tons, Nisshin 7,000 tons and Kawasaki 15,000 tons. In Europe, with the expiration of the quota system, the production figures from Ziegler and Maubeuge were not available as neither company is expected to produce for some time. Hoesch reported a quarterly production schedule for GALFAN at 12,000 tons for 1987. Galvanor is planning a trial in 1987 but so far no figures have been reported. Thyssen also plan to hold a production trial but no figures have yet been released. ICMI in Italy have planned a 1987 production trial which is expected to yield several hundred tons. In North America, Weirton expects to product between 10,000 tons and 15,000 tons of GALFAN. Stelco will be scheduling a trial in 1987 but no figures have been reported. In New Zealand a trial is expected in 1987 and no production figures have been reported. In India, Mr. Somani reported that H.K. Coated Sheets is installing a new line which will be ready for a production run at the end of 1987. GALFAN is expected to have better potential in India compared to Galvalume, particularly in the roofing market. The roofing demand in India is approximately 1 million tons, and the estimated demand for galvanized product is 1.2 million tons per year. Over the past 40 years India has been importing galvanized steel and all that has been imported has been consumed. The Indian government has only recently relinquished control of the importation of galvanized steel and has now enabled local companies to consider producing coated steel sheet. For 1987 the estimate is 55,000 metric tons of sheet to be produced. This is a minimum figure and does not include figures from other companies.

Mr. Hirose asked about the lower aluminum content being considered for the GALFAN bath standard. Frank Goodwin replied that the region between 4 and 5 percent aluminum needs to be investigated a bit more thoroughly and warrants investigation at several composition increments between 4 and 5 percent. Further tests should be run at compositions of 4.0, 4.3, 4.5 and 4.7 percent aluminum to determine the proper aluminum level. Mr. Coutsouradis noted that the aluminum content was covered in previous reports starting at 4.7 up to 6.2 percent. He said that 4.7 was selected by examination of the practice of producers who had made trials at that time. It was not specific technical data that was used to affix the 4.7 percent limit to the specification. The second concern was possible losses in corrosion resistance at lower aluminum contents. Mr. Hirose noted that there was no significant difference in the corrosion resistance when the level of aluminum is lower than 4.7%. Mr. Farge stated that there may not be a big difference in the corrosion resistance when the aluminum content is lowered but the formability characteristics at the lower aluminum content should also be examined.

Frank Goodwin noted that at the University of Cardiff, a paper was written that examined why GALFAN was ductile. They noted that the absence of intermetallics at the higher aluminum will not change the ductility significantly, however, when the aluminum content is lowered, some ductility is lost because the structure is not pure eutectic. Frank Goodwin also noted that in the operating session, best operating conditions were reported to be obtained below 5 percent.

Dr. Hirose stated that the proposal in Nippon Steel's research report had presented some data comparing GALFAN and Superzinc. He asked if there were any further comments on the proposal. Frank Goodwin noted that there were still some differences he observed in the performance of Nippon Steel's Superzinc and GALFAN.

Mr. Hoboh stated that he has some information on Sumitomo's third trial. He stated that Sumitomo reduced the aluminum content in the third trial to4.5%. During the second trial, the aluminum content was 4.0. In the first trial, the aluminum content was between 4.5 and 4.6 percent. He stated that Sumitomo's experience was that the 4.5 aluminum content gave the best results. Mr. Hoboh noted that there may be a slight decrease in the corrosion resistance but Sumitomo produces GALFAN for the coil coated applications. The aluminum content is reduced below 4.7 percent to overcome the grain boundary dent problem. He recalled his report of the previous day during the technical session where the grain boundary dent problem was presented.

Mr. Farge asked how CRM and ILZRO react to the fact that 4.2, 4.3, 4.5, 4.7 or 4.8 may be optimum aluminum percentages for the composition of GALFAN. He asked what plans ILZRO has to examine this problem. Frank Goodwin stated that ILZRO will incorporate in the GALFAN program a series of tests to examine the various aluminum contents and their effect on the ductility and corrosion resistance of GALFAN.

Ian Robertson asked why the galvanizing companies are looking at the lower limit of the aluminum composition. He asked if the grain boundary dent problem was the only reason why the lower limit was favored.

Dr. Hirose said that the grain boundary dent was the reason for looking at the lower limit. Frank Goodwin stated that Hoesch has been able to overcome the problem between 4.7 and 4.8 percent aluminum. Dr. Hirose stated that the customers in Japan are concerned with the aluminum limits in the coatings.

Ian Robertson asked if the aluminum content is the only way to overcome the grain boundary dent problem. Frank Goodwin stated that in the operating session, other methods of reducing the grain boundary dent were discussed. Dr. Kobo said that his examination and experience shows that the only way to reduce the grain boundary dent is to reduce the aluminum content. Sumitomo had also looked at other methods of reducing the dent problem.

Frank Goodwin asked if any of the operating persons could comment on the problem. Dr. Coutsouradis stated that the problem in Japan is the appearance of the product after painting. He then asked if the paint systems used in Japan are different from what are used in Europe or North America. Dr. Hirose stated that the Japanese paint systems were different.

Dr. Fuchs stated that the reason for the grain boundary dent was a physical effect related to cooling at the eutectic point. The operators need to move away from the eutectic point to overcome the dent formation. Dr. Fuchs asked tht ILZRO and CRM resolve as soon as possible the acceptable lower limit for the aluminum composition range. Frank Goodwin stated that ILZRO and CRM will focus their efforts towards resolving the matter.

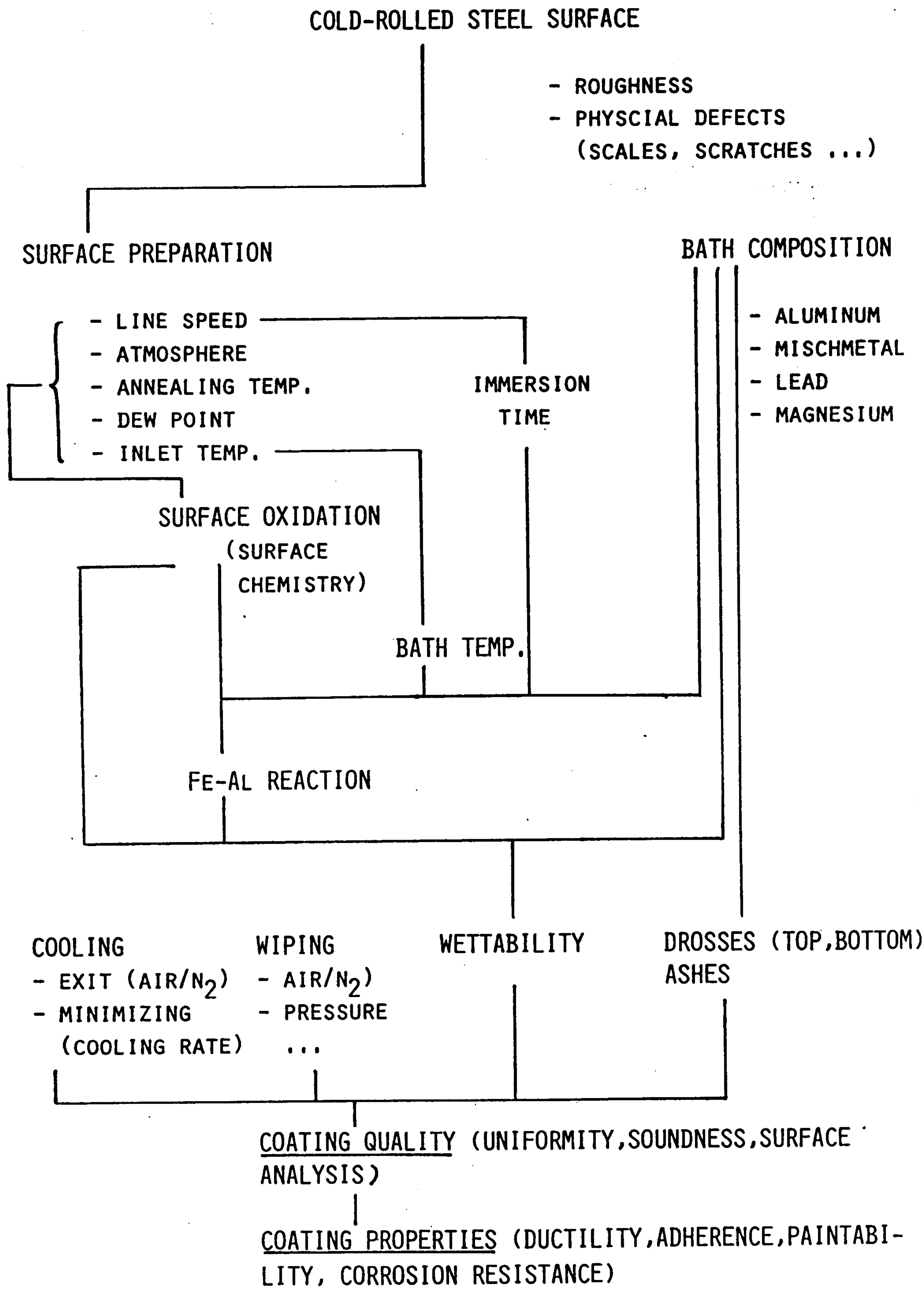
Mr. Wolf stated that Hoesch was not able to change their customers a higher price forGALFAN and asked if Weirton's higher charges for GALFAN was really accepted in the market place. Mr. Celestin replied that the higher prices were definitely accepted by the customers. He further explained that in order to command a higher price the GALFAN products should only be directed to end use markets where the GALFAN properties are superior to other coatings and the customer is dissatisfied with the performance of other products.

Mr. Mathews asked if there was a premium on the price of Galvalume supplied to the United States. Mr. Wolf stated that to the best of his knowledge there are no extras on the price of Galvalume in the United States.

As there were no further comments Frank Goodwin noted that Weirton Steel has volunteered to host the next GALFAN meetings in Pittsburgh, Pennsylvania in 1987, and Weirton will try to schedule a GALFAN production run at that time. The best time will be the week of May 18th, 1987.

MEETING ADJOURNED

As there were no further comments, Frank Goodwin thanked everyone for attending and the meeting was adjourned at 12:30 p.m.


COLD-ROLLED STEEL SURFACE
- ROUGHNESS
- PHYSCIAL DEFECTS
(SCALES, SCRATCHES ...)
SURFACE PREPARATION
BATH COMPOSITION
- LINE SPEED
- ATMOSPHERE
- ANNEALING TEMP.
- DEW POINT
- INLET TEMP.
IMMERSION TIME
- ALUMINUM
- MISCHMETAL
- LEAD
- MAGNESIUM
SURFACE OXIDATION
(SURFACE CHEMISTRY)
BATH TEMP.
FE-AL REACTION
COOLING
- EXIT (AIR/N2)
- MINIMIZING
(COOLING RATE)
WIPING
- AIR/N2)
- PRESSURE
...
WETTABILITY
DROSSES (TOP,BOTTOM)
ASHES
COATING QUALITY (UNIFORMITY,SOUNDNESS,SURFACE ANALYSIS)
COATING PROPERTIES (DUCTILITY,ADHERENCE,PAINTABILITY, CORROSION RESISTANCE)

COATING DEFECTS

NAME	ORIGIN	SOLUTIONS
- BARE SPOTS	- POOR SURFACE ACTIVATION - IMPROPER REDUCTION	- DEW POINT REDUCTION - INCREASE OF AX-GAS - DECREASE OF LINE SPEED - INCREASE OF INLET TEMP. - INCREASE OF ANNEALING TEMP. - BATH COMPOSITION (MM)
- CRATERS	- POOR WETTABILITY - ASHES INSIDE THE SNOUT { COLD GAS INJECTION (SNOUT) { NEAR THE BATH SURFACE WIPING CONDITIONS - STRIP SEIZURE ON THE ROLLS BEFORE IMMERSION	- ID. - ASHES ELIMINATION - GAS INJECTION AT HIGHER POINT - WIPING MODIFICATION

COATING DEFECTS

NAME	ORIGIN	SOLUTIONS
- SURFACE INCRUSTATIONS - INCRUSTATIONS - EDGE BUILD-UP - GIBBOSITY Protuberance BUILD-UP WITH BARE ZONE HORSE SHOE DEFECT	- ENTRAPMENT OF DROSSES (TOP, BOTTOM) - PARTICLE OF REFRACTORIES FROM THE SNOUT (AL_2O_3, SI ...) - ENTRAINMENT OF TOP DROSSES ON SHEET EDGES - WIPING CONDITIONS	- WIPING PARAMETERS (PRESSURE, ANGLE ...) - "FILTERING" OF BATH - CLEANING OF BATH SURFACE
- FISH BONES - FINE VERTICAL LINES GROOVE DEFECTS COATING SAGS	- ENTRAINMENT OF ASHES (AL_2O_3) WITH EVENTUALLY PECULIAR CRYSTALLIZATION - DEFECT OF THE STEEL (SCRATCH) - IMPROPER WIPING CONDITIONS - LOW LINE SPEED	- WIPING PARAMETERS NOZZLE PROFILE NOZZLE HEIGHT OVER BATH PRESSURE FLOW RATE...

COATING DEFECTS

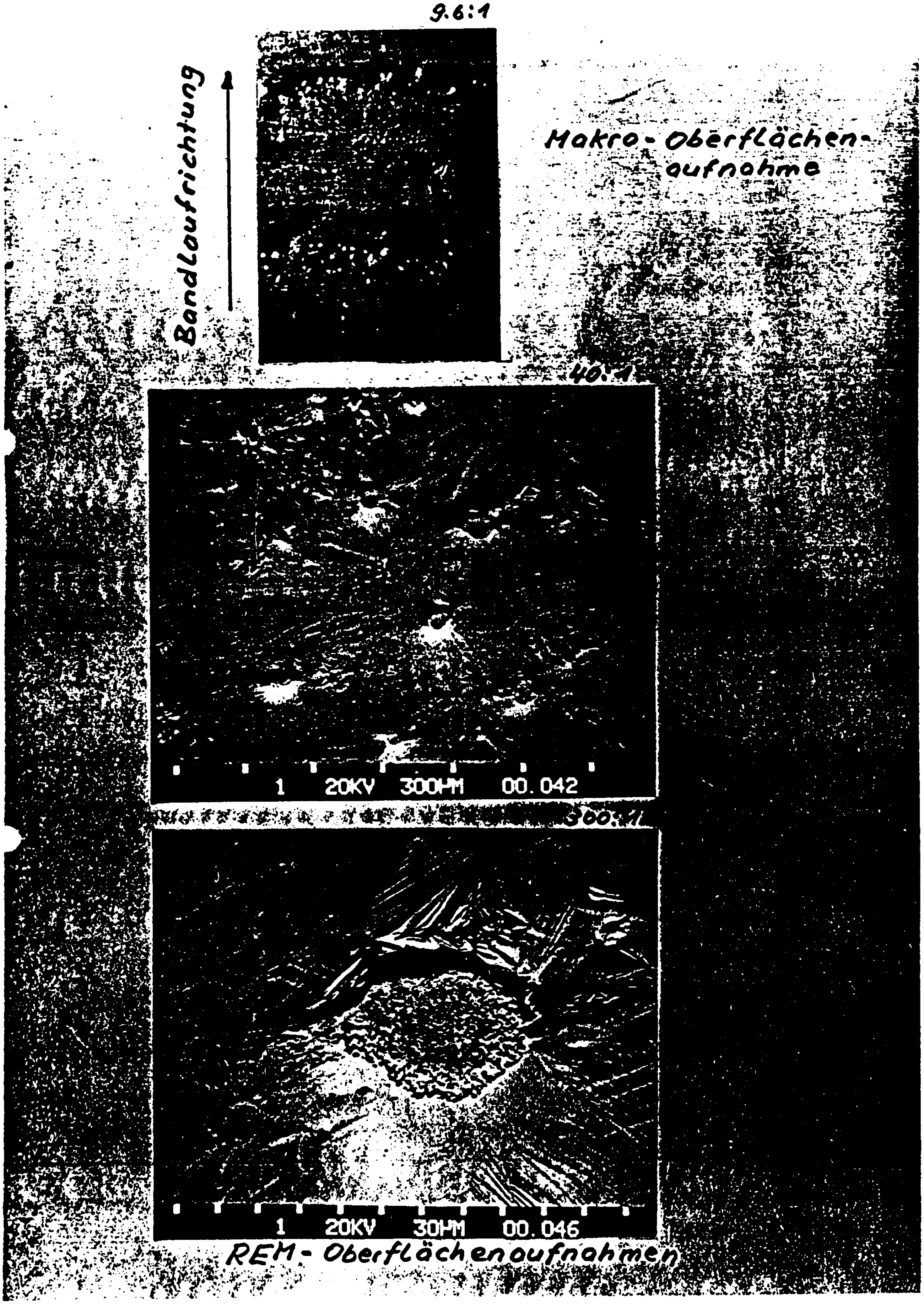
NAME	ORIGIN	SOLUTIONS
- RIPPLES	- VIBRATION OF STRIP - FLUIDITY OF GALFAN - INTERACTION BETWEEN WIPING AND OUTER LAYER - WIPING TOO STRONG (PRESSURE)	- NITROGEN EXIT AND WIPING - INCREASE OF BASE METAL ROUGHNESS - SOFTER WIPING
- EDGE OVERCOATING	- WIPING	- DESIGN OF NOZZLES
- UNCOATED AREAS	- WIPING TOO STRONG - THIN GAUGES AND LIGHT COATINGS	- WIPING PARAMETERS (PRESSURE,FLOW RATE)

COATING DEFECTS

NAME	ORIGIN	SOLUTIONS
- HOLES AT GRAIN BOUNDARIES	- PRESENCE OF ZIRCONIUM NUCLEATION AGENT	
- WAVES	- OXIDATION DURING COOLING - PARTICLE OF REFRACTORIES FROM THE SNOUT	- NITROGEN EXIT AND WIPING
- GRAIN BOUNDARY DENT OR SHRINKAGE	- COOLING CONDITIONS - BATH COMPOSITION (EUTECTIC) - HEAVY COATING WEIGHT	- INCREASE OF COOLING RATE - DECREASE OF AL CONTENT - SKIN-PASS

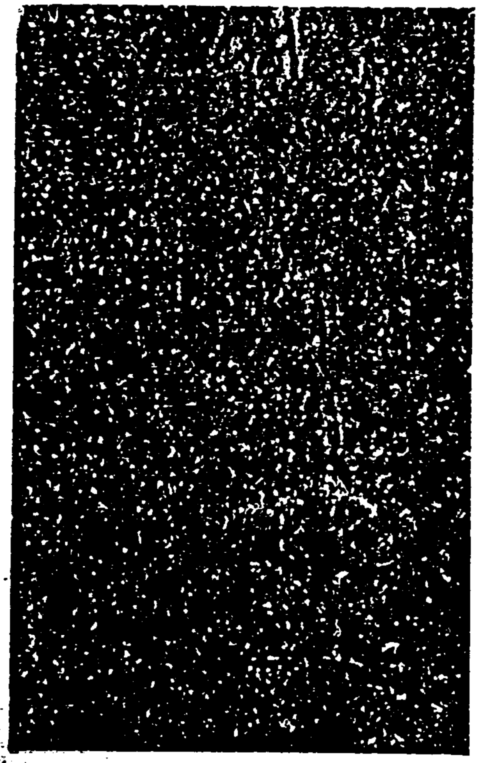
1) Ripples / Tears

2) Ripples and holes

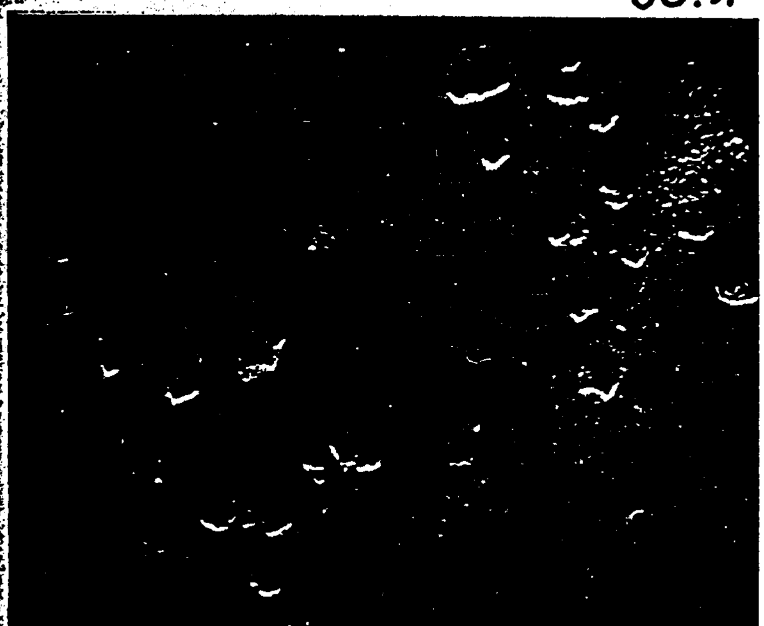


3) Ripples and holes

1:1



30:1

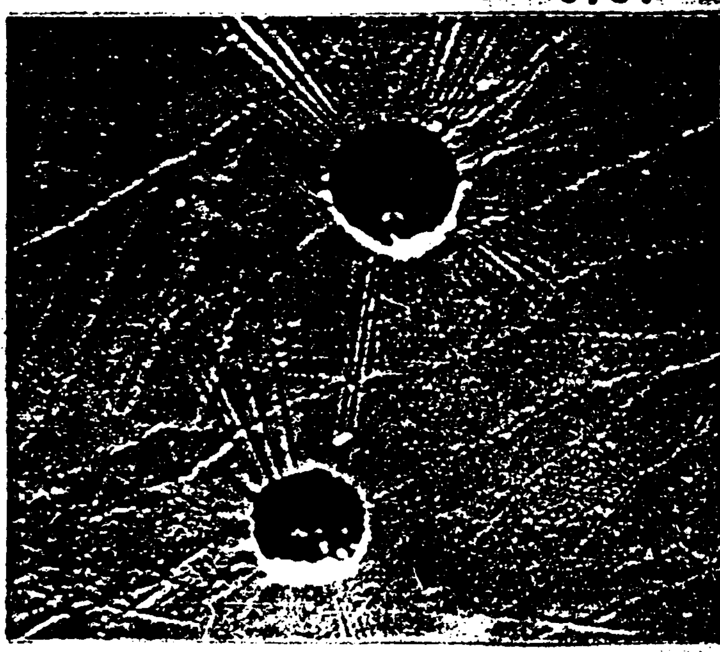


REM - Oberflächenaufnahme

4) holes

300:1

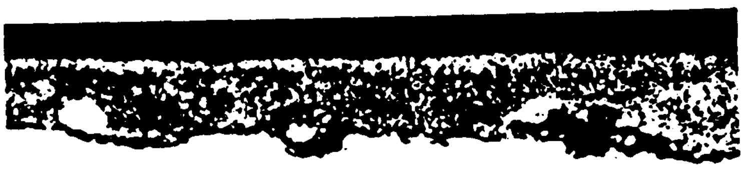
370:1



REM- Oberflächenaufnahmen

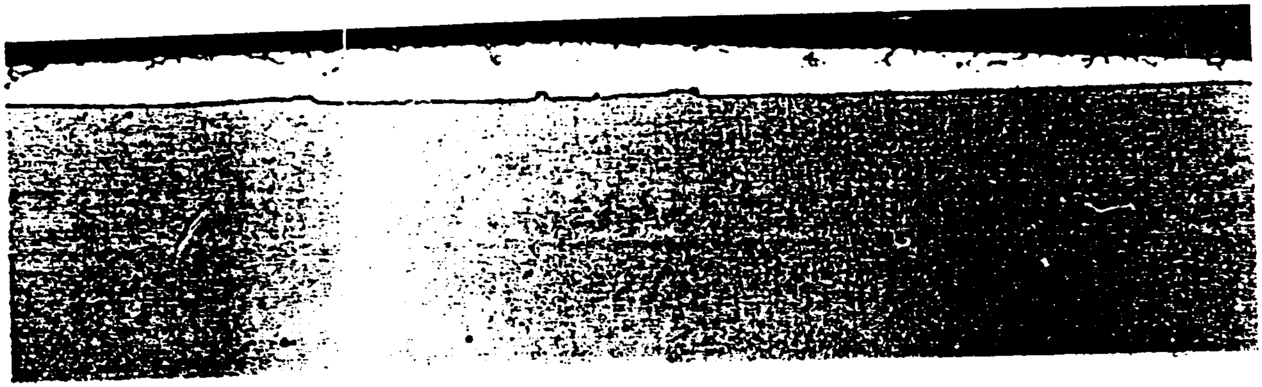
5) micro-section of holes

500:1

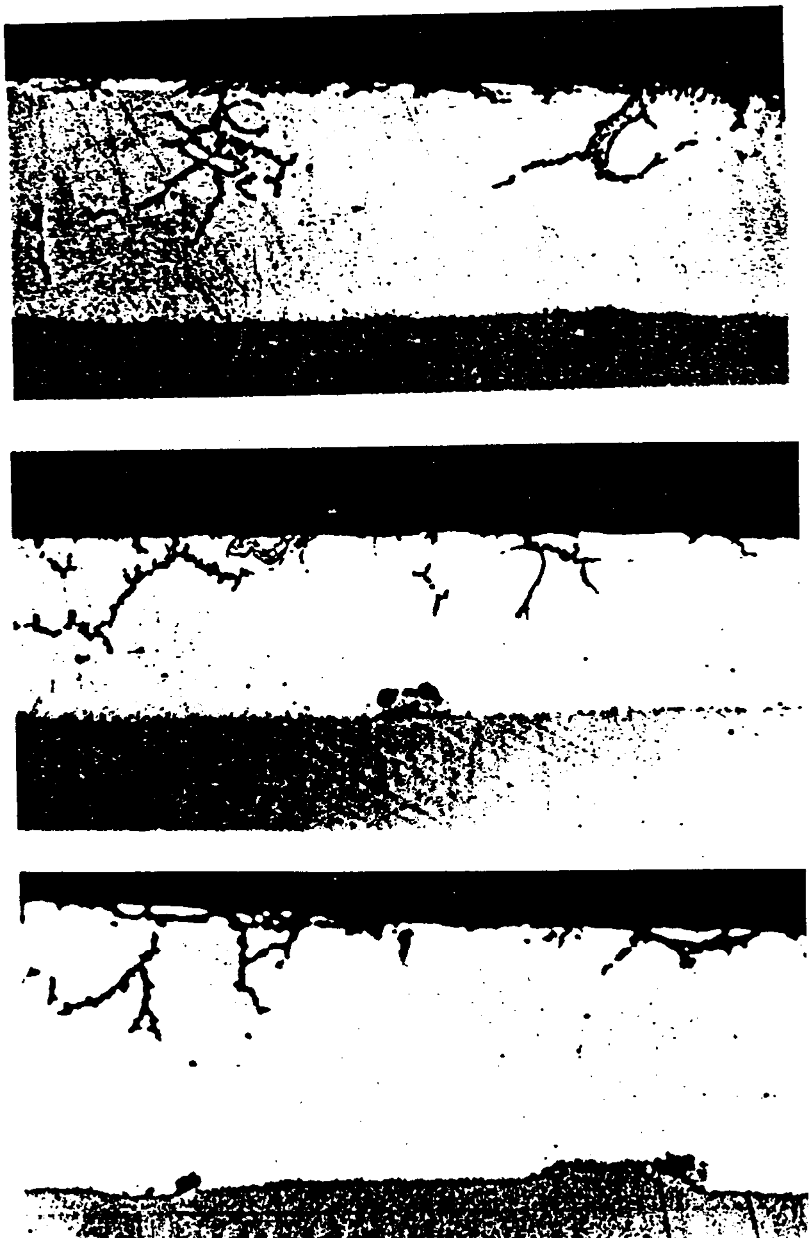


6) micro-section of ripples with Al-oxidation

100:1



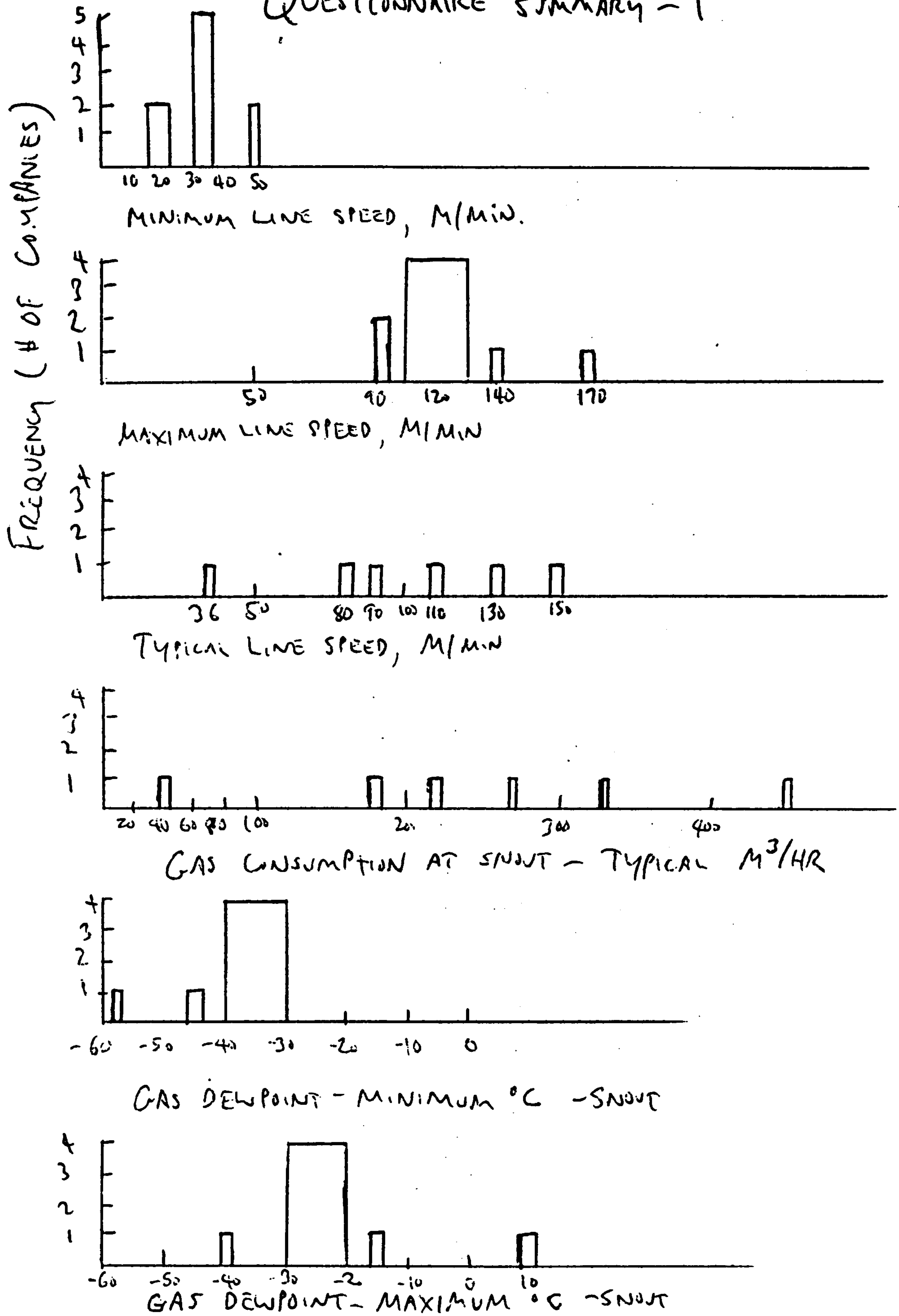
500:1



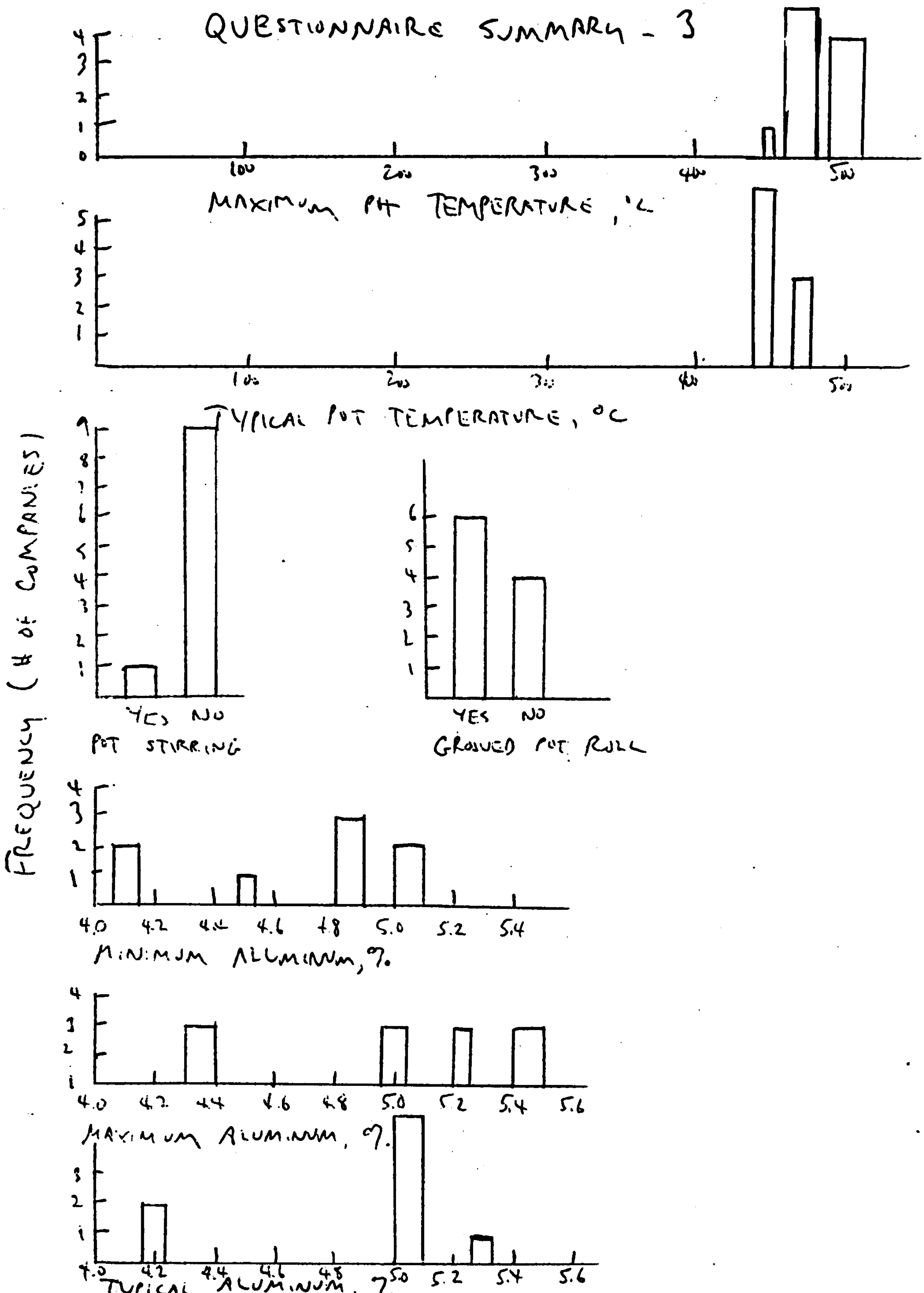
COATING DEFECTS SUMMARY

NAME	CAUSE	SOLUTION
Carters/Bare Spots	Cleanliness of Strip Composition of Mischmetal Improper Dewpoint	Reduce Dewpoint Increase AX Gas Prolong Seasoning Time Lower Line Speed High Annealing Temperature Elevate Strip Temperature to Pot Clean Strip
Waves/Ripples	Too Smooth Surface	Knife Design Temperature (higher bath) Nitrogen Wiping Soft Blow Wiping Increase Base Metal Roughness
Grain Boundary Dents	High Aluminum	Skin Rolling Higher Cooling Lower Al in Bath to 4.7 - 4.8
Sagging/Edge Overcoat	Heavy Gauge Low Line Speed	Modify Wiping Nozzle Profile Change Nozzle Height Above Bath
Fishbones	See CRM Report	
Black Patina	Darkeing After Chromating	Under Investigation
Small Gibbosity (Coating Inclusions)	Mischmetal Content Too High	Reduce mm Content
Grain Shape Defect (Horseshoe)		Run with Pot = 470°C and Strip = 500°C
Grain Boundary Cracking		Lower Pot Temperature

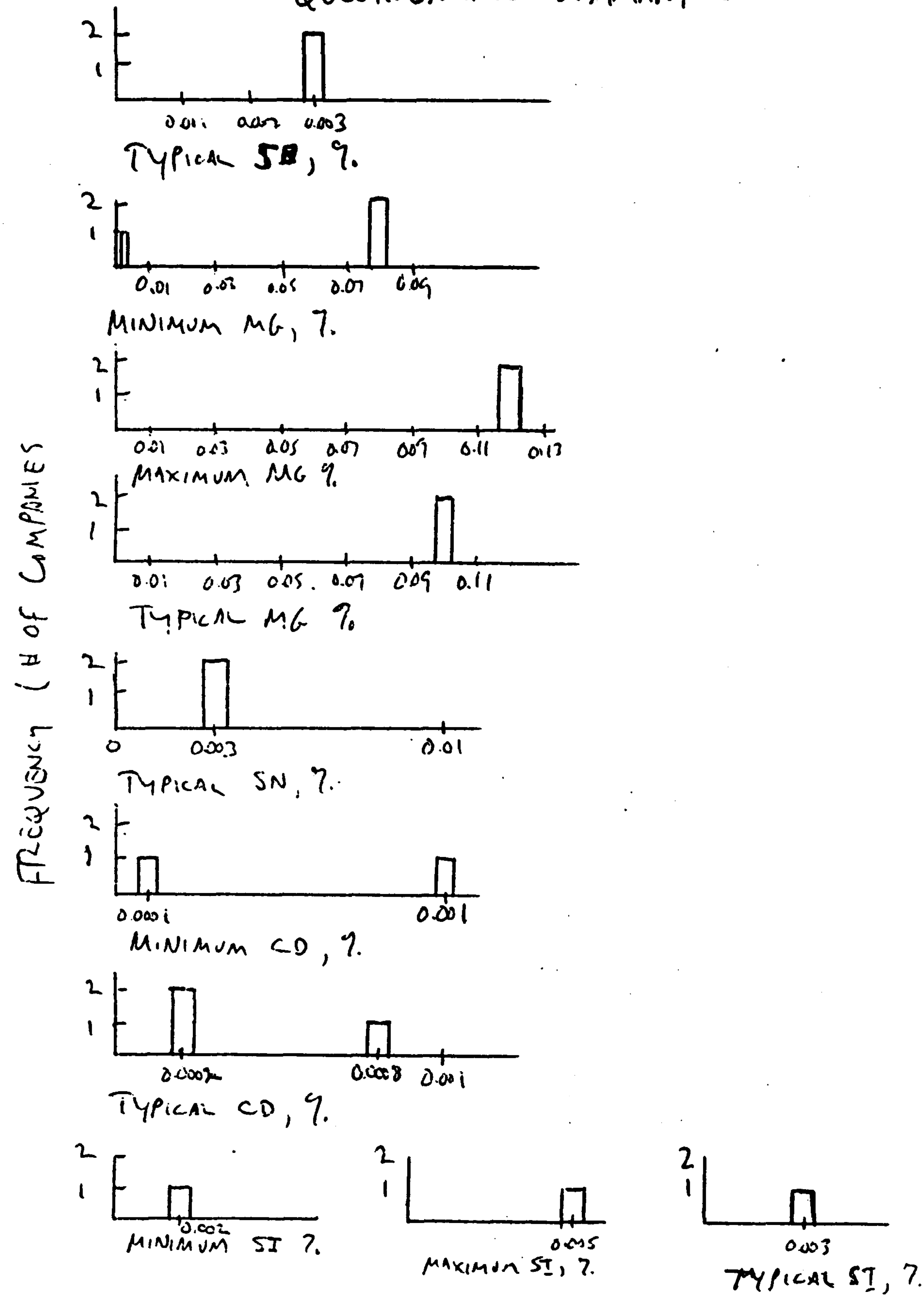
QUESTIONNAIRE SUMMARY - 1



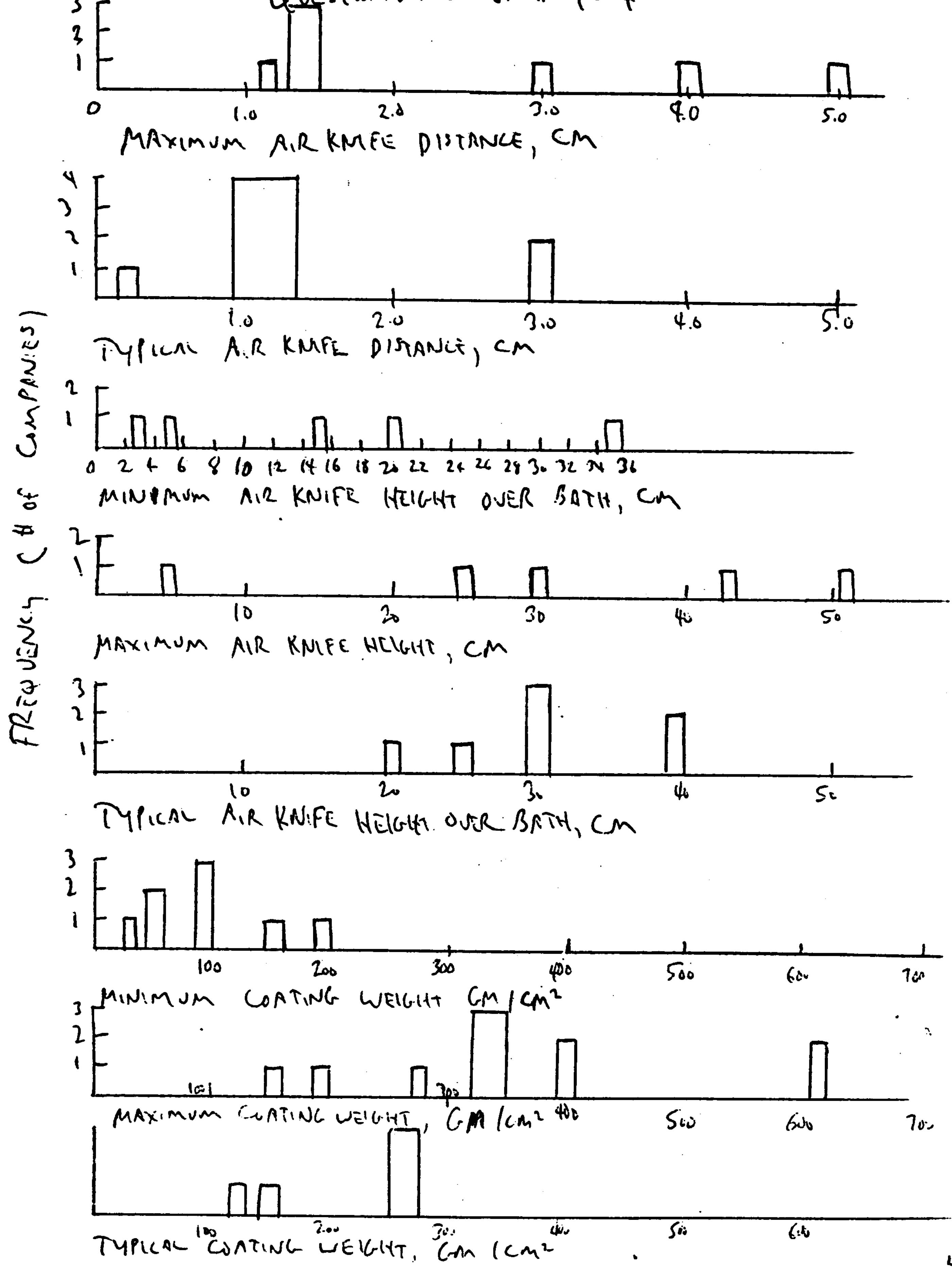
QUESTIONNAIRE SUMMARY - 3



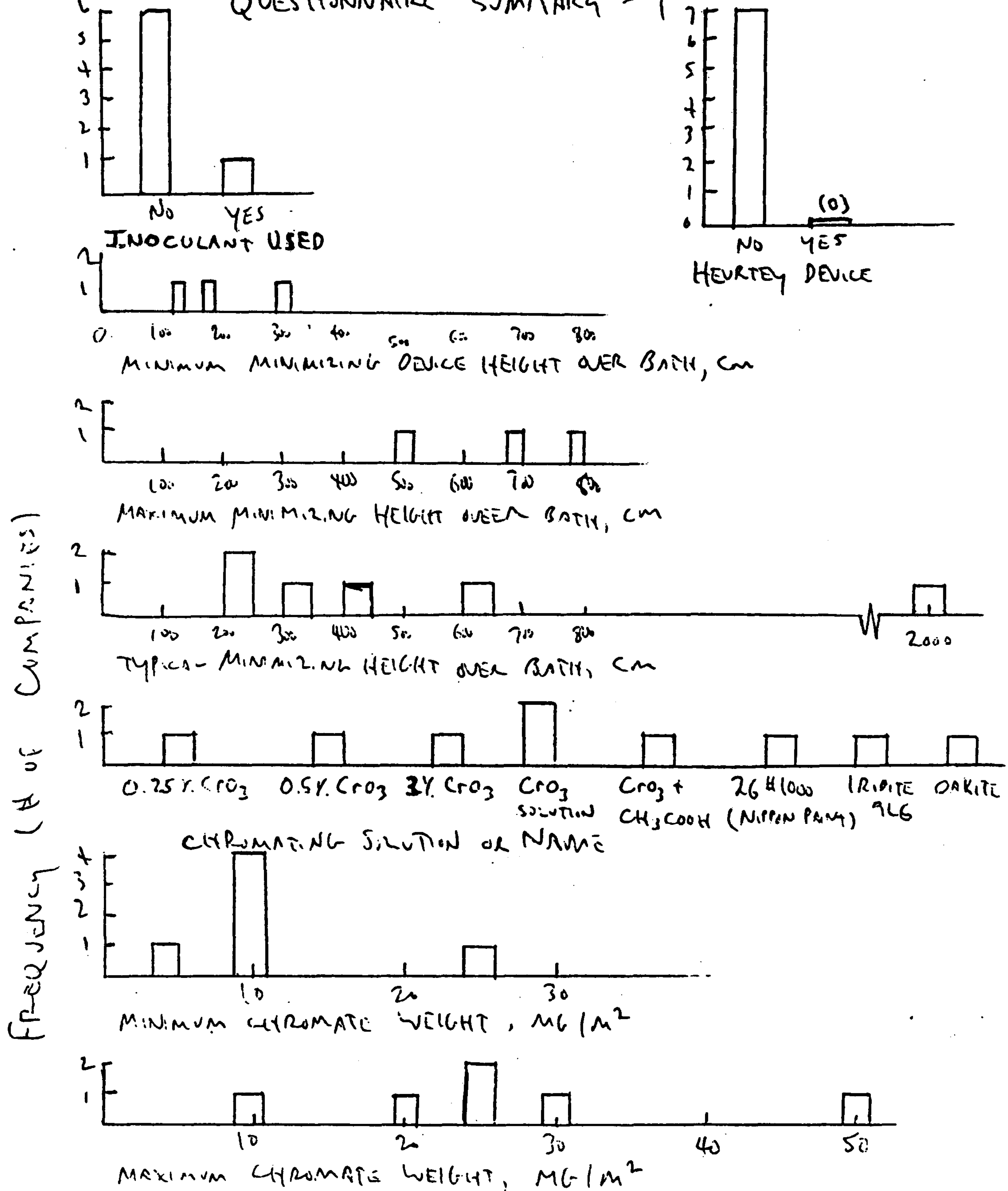
QUESTIONNAIRE SUMMARY - 5



QUESTIONNAIRE SUMMARY - 7



QUESTIONNAIRE SUMMARY - 9



November 1986

GALFAN - Production at Hoesch Stahl AG in 1986

On the hot dip galvanizing line in Eichen we produced in four campaigns at total of 14.500 tons. Production is being carried out as test runs, i.e. we pump zinc from the pot and keep it liquid within another pot. GALFAN-blocks are then being melted and after completion of the campaign GALFAN is poured to ingots, cooled and set aside for the next campaign. The overall time of change of the system is 56 hours.

The pot used in Eichen is made from special Iron material having acceptable life for normal galvanizing.
When producing GALFAN corrosion rate of the walls was appr. 1 millimeter per day. The corrosion rate with GALFAN has been reduced a lot by careful and complete plating with Stelite. Costs of the pot, however, have practically doubled by this, but only due to this plating has it become possible to carry out our campaigns in a normal iron pot with normal times for a changeover of pots.

We have to get along with typical GALFAN-defects and, therefore, we have tried within our campaigns various experiments.

The results of these experiments are summarised below:

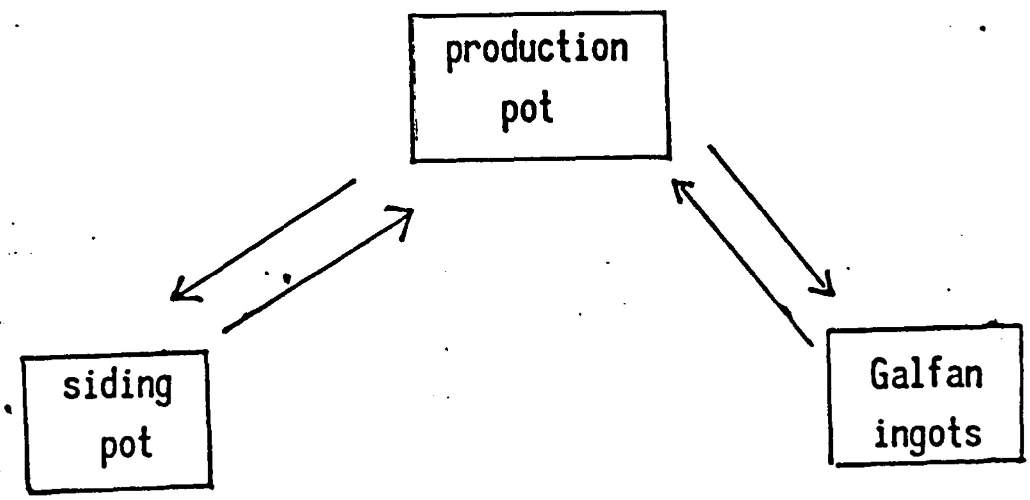
1. We have observed that the top dross is between 1.3. and 1.6 kg/t per production and thus only one third of the dross production with normal hot dip galvanizing.

2. The radiation measuring systems in galvanizing lines for measuring the coating show consideralbe variations when measuring the GALFAN Coating. Most systems for measuring the zinc coating operate according to the X-ray-fluorescence method. By this method the radiation of the zinc is being measured and, therefore, due to the portion of aluminum in GALFAN, the measured coating is bound to be lower. When evaluating statistically the coating - compared to the results of wet stripping - we have to reckon with an error indication of appr. 10 %. For instance 250 g/m^2 as per measurement and 270 g/m^2 per wet stripping.

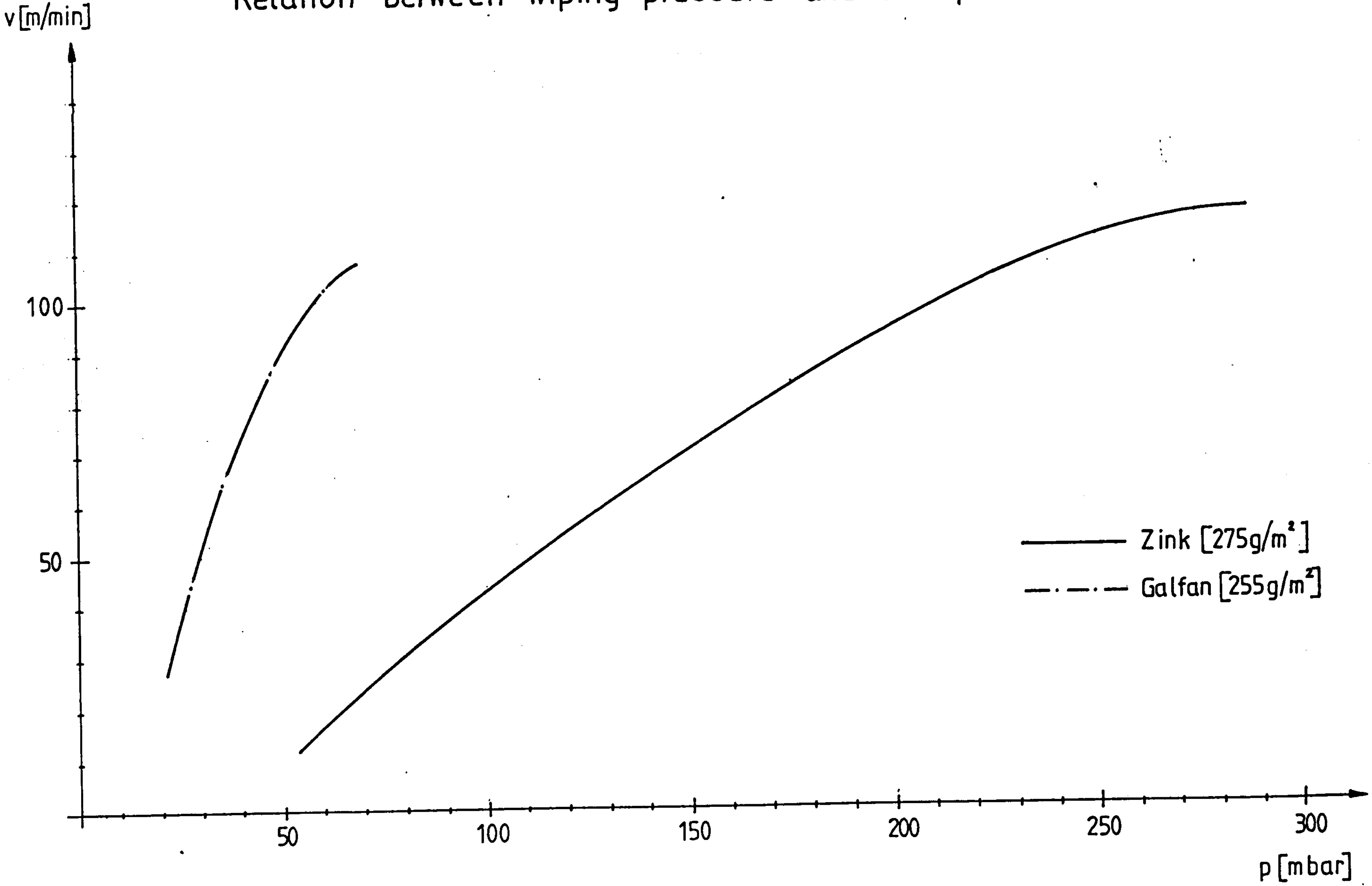
3. <u>For wiping</u> the GALFAN considerably lower air pressures are required with air jet wiping. Higher pressures cause the GALFAN-typical faults of ripples and tears - we shall revert to these later.
   In order to avoid these ripples and tears it is essential, within certain limits, to use nitrogen instead of air.

4. <u>The temperatur of the bath</u> and the thickness of the strip have a

Changing system



Relation between wiping pressure and linespeed



significant influence on the formation of ternary intermediate phases. Especially with strip above 1,50 (.060) mm thickness. It has happened that this ternary phase reaches the surface, resulting in very bad results in a corrosion test. Therefore, it is to be recommended, depending on thickness, to use various bath temperatures, e.g.

450 °C up to 0,8 mm thickness 842 < .032

440 °C up to 1,5 mm thickness 824 - .060

430 °C over 1,5 mm thickness 806 > .060.

See now, the effect of adding Si.

5. Aluminum-Content of the Bath

In order to achieve a good eutectic appearance in the GALFAN-coating, the concentration of aluminum should be over 5 %. This concentration, however, has two important disadvantages:
The dents of the grains are larger with increasing aluminum content. Then it is no longer possible to obtain a smooth surface, especially with a view to colour coating.
Furthermore we have observed a buildup of GALFAN on the rolls of the tempermill and the bending rolls of the Stretcher leveller. Therefore, it is recommended to stay at the lower limit of the GALFAN-concentration.

6. Special attention has to be given to a constant analysis of the bath. This analysis varies considerably. It could be

Should use SPC

Relation Gauge / Temperature

Gauge	Temperature
≦ 0,80 mm	450 °C
≦ 1,50 mm	440 °C
> 1,50 mm	430 °C

Analysis of GALFAN-Ingots

Location of Specimen	% Al	% Pb	% Ce	% La	% Fe
GALFAN-Ingot I					
top	6,81 - 6,89	0,001	0,058	0,029	0,118
bottom	5,16 - 5,22	0,001	0,012	0,007	0,005
side	5,25	0,001	0,013	0,008	0,065
GALFAN-Ingot II					
top	6,38 - 6,93	0,001	0,065 - 0,118	0,075 - 0,139	0,077 - 0,180
bottom	5,13 - 5,18	0,001	0,010	0,014	0,006
side	5,23	0,011	0,011	0,015	0,006
GALFAN-Ingot III					
top	5,01 - 5,05	0,001	0,022	0,025	0,025
bottom	4,54 - 4,62	0,001	0,014	0,016	0,009
side	4,72 - 4,84	0,001	0,012	0,015	0,007

due to reactions between strip and bath or perhaps it might resul from irregularities of the ingots. Drilling-analysis has shown differences between the upper and lower side of a GALFAN ingot.

I shall revert in short to the ripples, tears and dents of the grain previously mentioned:

1. Ripples and tears appear separately or side by side on the surfac Ripples as well as tears are local concentrations of the coating. Below these concentrations the coating is very thin (below 5 μm). The primary α zinc-rich-crystals in these areas of thin coating reach through to the surface.

   Especially below the ripples where the coating is very thin there is often a number of small holes (so-called black pin-holes). The holes reach to the steel surface and this means that the surface has not been wetted. The reason for this could until now not be found. We suppose that the stronger formation of an aluminum-oxide-skin on the liquid coating results in an increased tension of the surface, which prevents a uniform flow of the melt, i.e. this leads to the formation of ripples and tears.

2. Deep Grain Boundaries

On the surface of GALFAN you can find frequently deep grain boundaries (dents).

We have observed that the formation of the GALFAN-surface depends on the total Al-content and on the volume fraction of primary crystals. With increasing volume of the primary crystals the surface gets diffuse solidification contours and the dents of the grains are lower.

On the contrary a significant structure of grain boundaries will occur the closer you get to the eutectic composition, i.e. the larger the proportion of eutectic component the greater the dents.

Summarizing we can say that hot-dip coating with GALFAN and the solidification after coating differ considerably from galvanizing. We have to deal with different faults and their reasons. We are at the beginning of GALFAN development and see that al ot of work still has to be done, before we understand its coating characteristics.

PRODUCTION OF GALFAN AT WAKAYAMA STEEL WORKS

SUMITOMO METAL IND.,LTD.

TRIALS AT WAKAYAMA STEEL WORKS

	FIRST	SCOND
Date :	MAY 19, '86	AUG. 15~16, '86
THICKNESS :	0.35~0.60 mm	0.27~1.5 mm
WIDTH :	914 mm	914~1000 mm
QUANTITY :	90T	450T
COATING WEIGHT :	50~250g/㎡	180~250 g/㎡

Conditions of Production

- Chemical Composition of Ingot and Bath

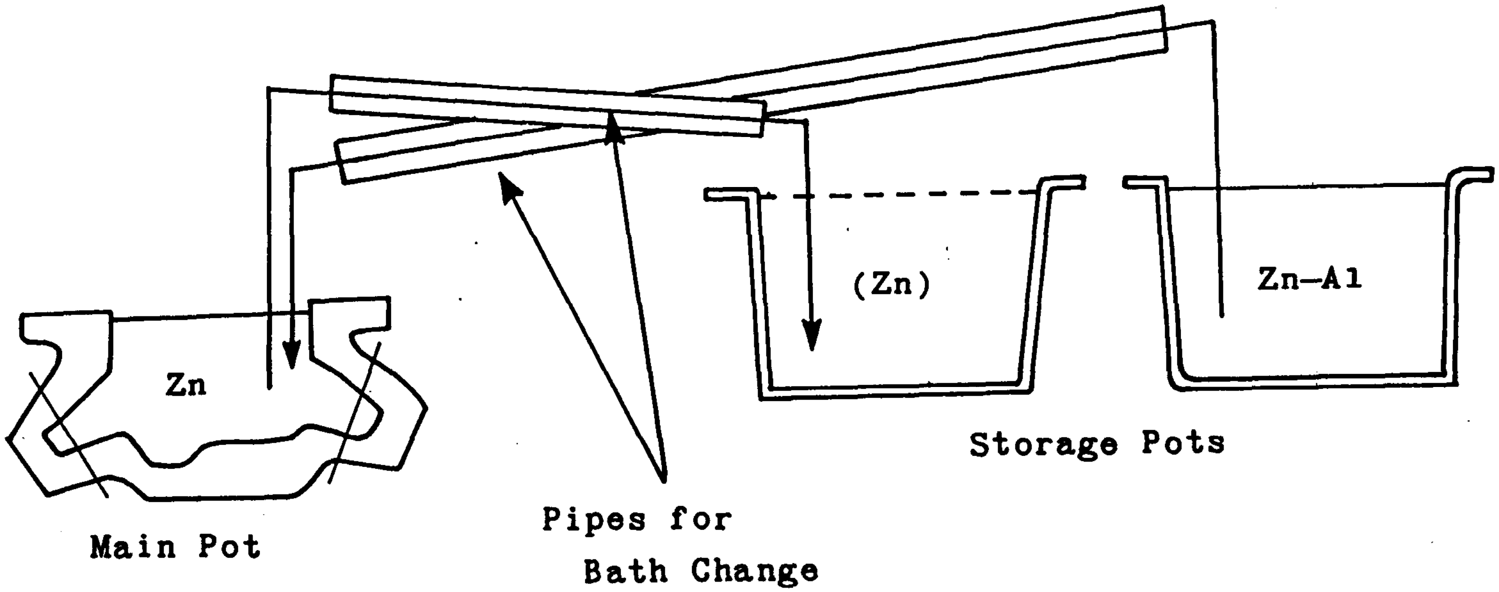
	Al	Ce	La	Pb	Fe
Ingot	4.8～5.2%	0.06%	0.03%	below 0.003%	below 0.03%
Bath	4.5～5.0%	0.002%	0.001%	〃	〃 0.01%

- Bath Temperature ---------------------- 470℃ 878
- Strip Temperature at Snout ------------- 470 ～ 500℃ 878 – 932
- Annealing Temperature ----------------- 720℃ 1328
- Dew Point (at Cooling Zone) ------------- below – 35℃ -31
- Wiping Nozzle Distance ----------------- 17 ～ 22 mm .67 – .87

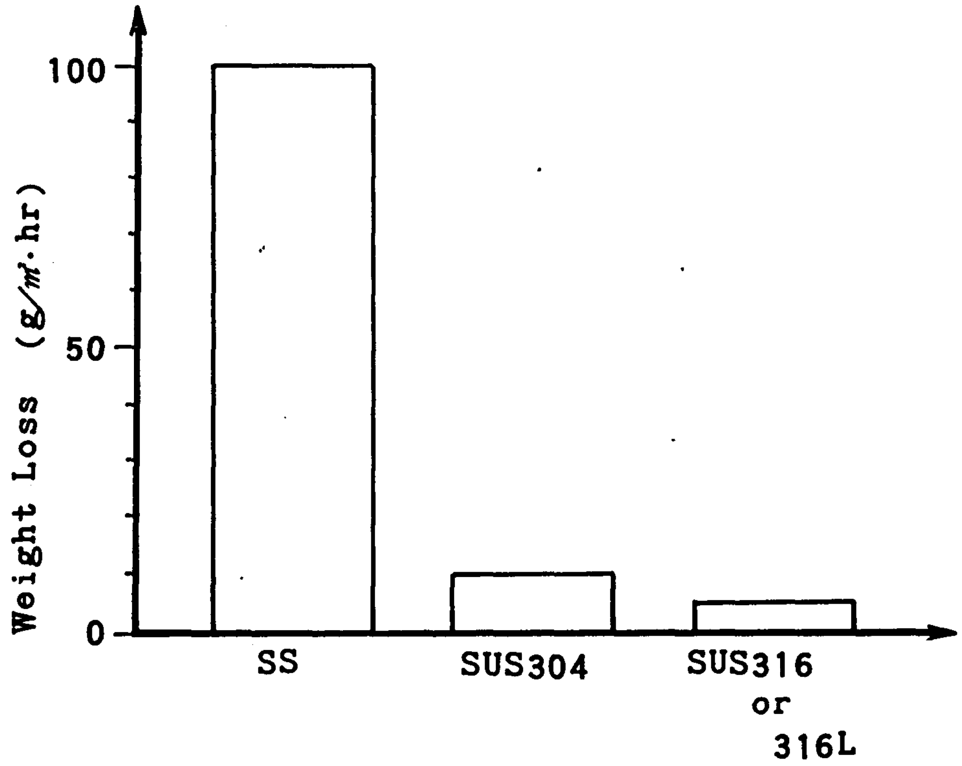
Time for Bath Change

$Zn \rightarrow Zn - A\ell$	16 hr.
$Zn - A\ell \rightarrow Zn$	13 hr.

(Pumping – up of bath takes 30minutes each)



Bath Changing Equipment



Weight Loss of Metal in Zn–5%Al Bath

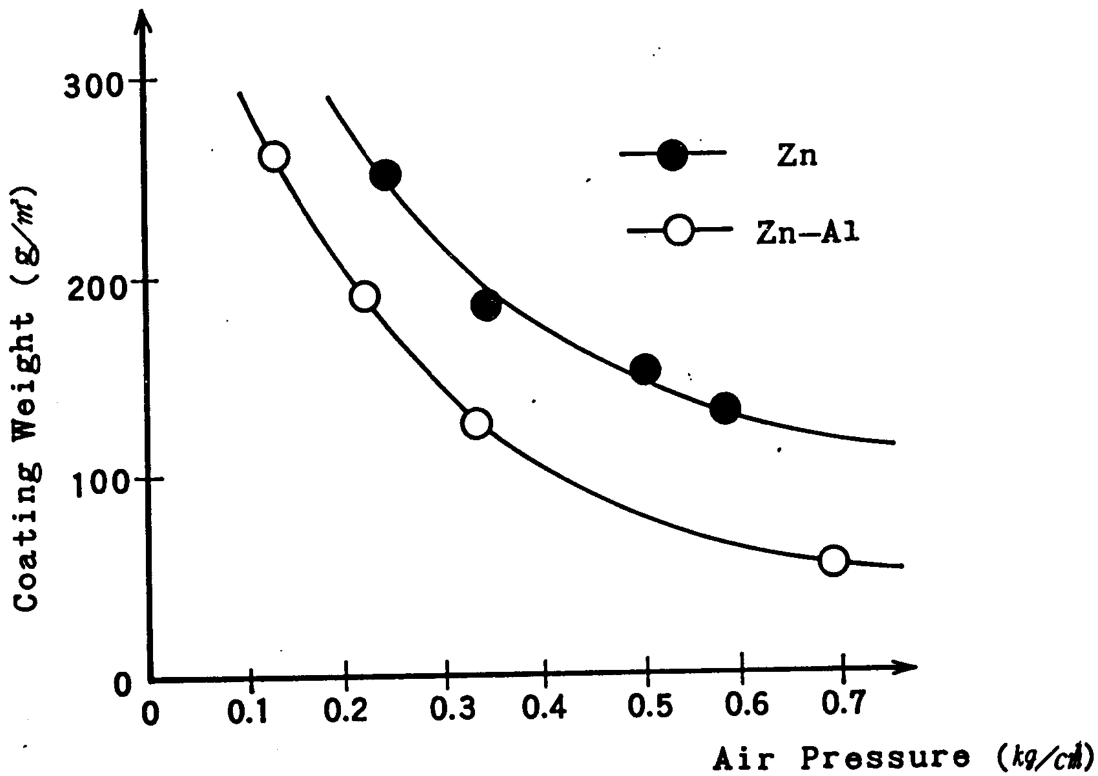
– Experimental Results –

Material for Machine Parts in Zn-Al Bath

	Past	Present
Sink Roll	SN-1	SUS316L
Sink Roll Support	SUH309	〃
Stabilizing Roll	RGA	〃
Stabilizing Roll Support	SUH309	〃
Stabilizing Roll Drive Shaft	SUS304	〃
Snout	Steel	〃
Storage Pot	-	SUS316

Composition of Zn–Al Bath (%)

		Ingot	Storage Pot	Main Pot	
				betore test	after test
Al	Top	4.8~5.2	4.89	4.53	4.50
	Middle		4.88	4.55	4.59
	Bottom		4.72	4.68	4.55
La and Ce	Top	0.06 ~0.09	0.004	0.003	0.006
	Middle		0.004	0.003	0.006
	Bottom		0.062	0.003	0.006



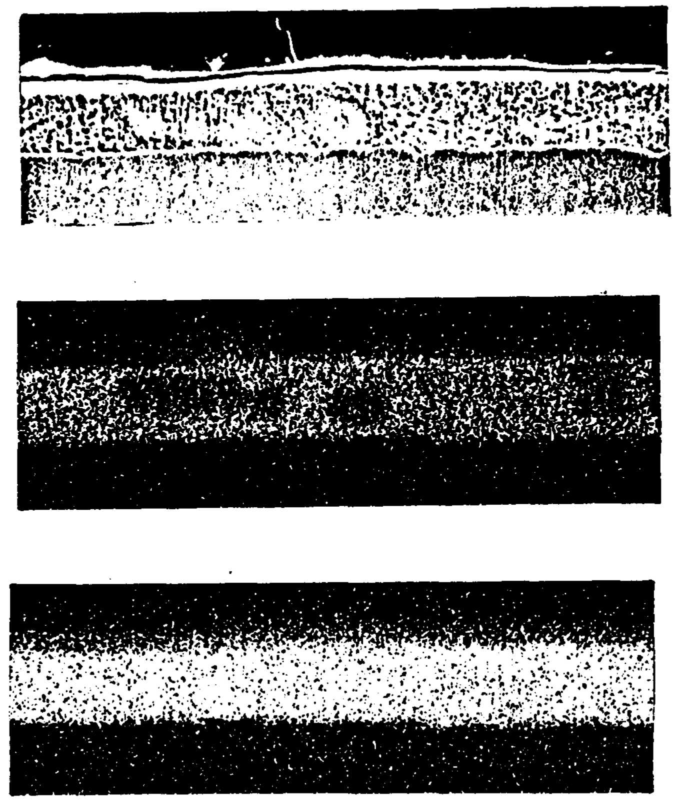
Comparison of Coating Weight between Zn and Zn–Al

(Line Speed : 105mpm
Nozzle Distance from the strip : 10 mm)

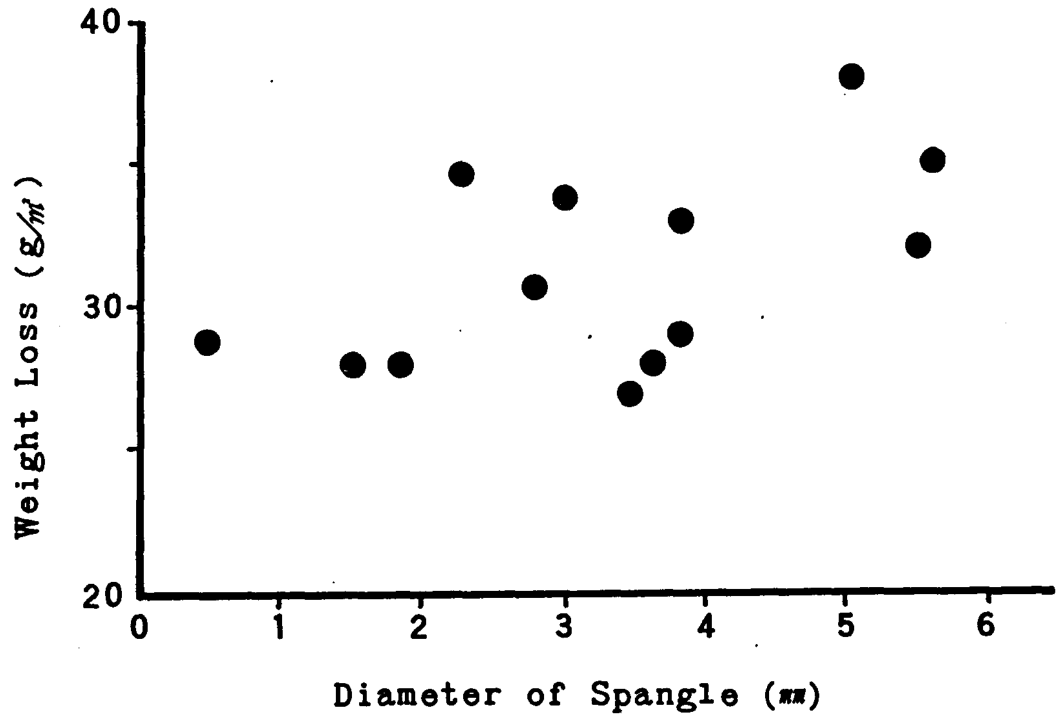
SEM

EPMA (Al)

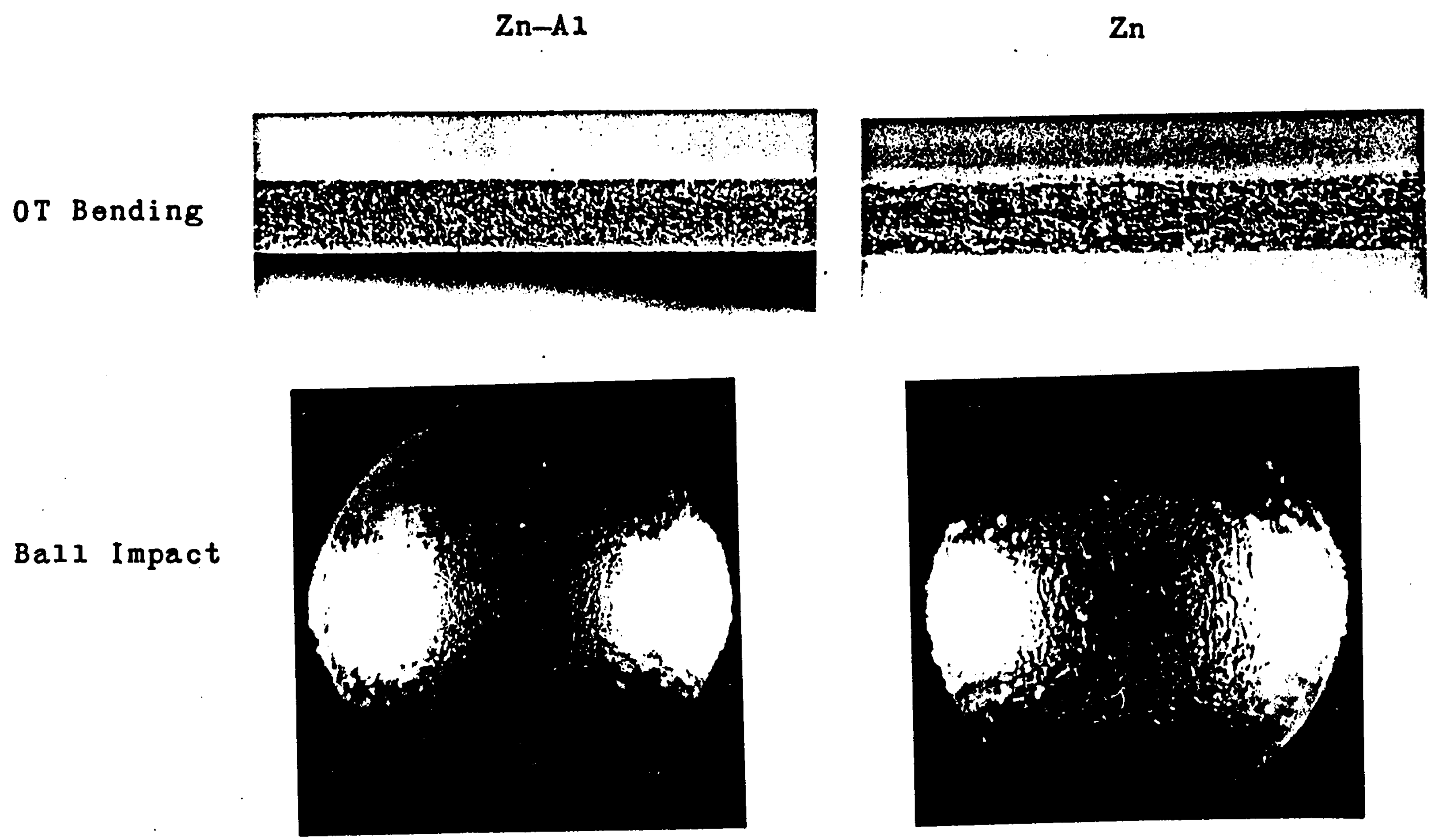
EPMA (Zn)



Cross Section of Coating Structure. 10 μm



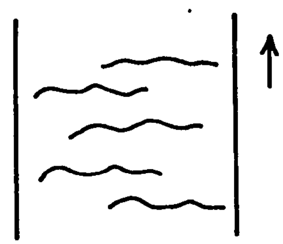
Weight Loss of Zn–Al coating
(Salt Spray Test 96 hrs.)
Zn:About 96 g/㎡)



Assessment of Peeling and Cracking

COATING DEFECTS OBSERVED

(1) RIPPLE



(2) GRAIN BOUNDARY DENT

Improvement of Bath Exchanging Process at GALFAN

November 12,1986

Kawasaki Steel Corp.
Kawatetsu Galvanizing Co., Ltd.

9 th Galfan Licensees Meeting
Crest Hotel, Siegen, West Germany

1. Introductin

GALFAN production at Kawatetsu Galvanizing Co., Ltd. (KGC.) Chiba Works on No.2CGL started as the trial in January, 1984, and the production was carried out 17 times until October 1986. Thus the total production has amounted to about 15,000 t.

Since May, 1986, a production chance has been provided once a month, and bath exchange time became a serious problem in GALFAN production.

3-pot bath exchange method has been adopted for bath exchange, as reported by Shijima at the 5th Licensees Meeting. The conventional bath exchange time according to this method, took about 10 hours on one way.
After various expriments, this bath exchange time has been shortened.

The following is the report on the approach for shortening the bath exchange time.

2. Improvemants of bath exchang method for shortening the time.

The transition of bath exchange time is shown in Fig.1. In the past, bath exchange took about 10 hours on one way, but at present, bath exchange can be made with in 2 or 3 hours, if pot equipments (sink roll,stabilizing rolls and air knives) does not need to remove.

Schematic diagram of bath exchange method is shown in Fig.2.

Major improvements are as follows:

1) Shortening of gas purge time in the furnace by the adoption of the blast gate hood.
2) Omission of pump setting up by use of fixed 2 zinc pumps and omission of heat-holding operation of ceramic pot refractories.
3) Shortening of a molten metals carring pipeline set up time by adoption of pre-fab pipeline.
4) Omission of GALFAN make-up operation at the main pot by increasing the sub-pot capacity and adoption of make-up in it.
5) Decreaseing the generation of the top dross by N_2 gas sealing on the molten metal discharge part.
6) Omission of pot equipment removing and decreasing the amount of residual molten bath metal.

Conventional and improvement operation processes of bath exchange are shown in Fig.3. Also the balance of molten bath metal and bath composition at the time of bath exchange are shown in Fig.4.

3. Conclusion

Bath exchange during GALFAN production at KGC., Chiba Works on No.2 CGL took 10 hours in the past, but as a result of various exprimants, bath exchange time has been shortened up to 2 to 3 hours, therefore product-type change between galvanizing and galfanaizing has become easier.

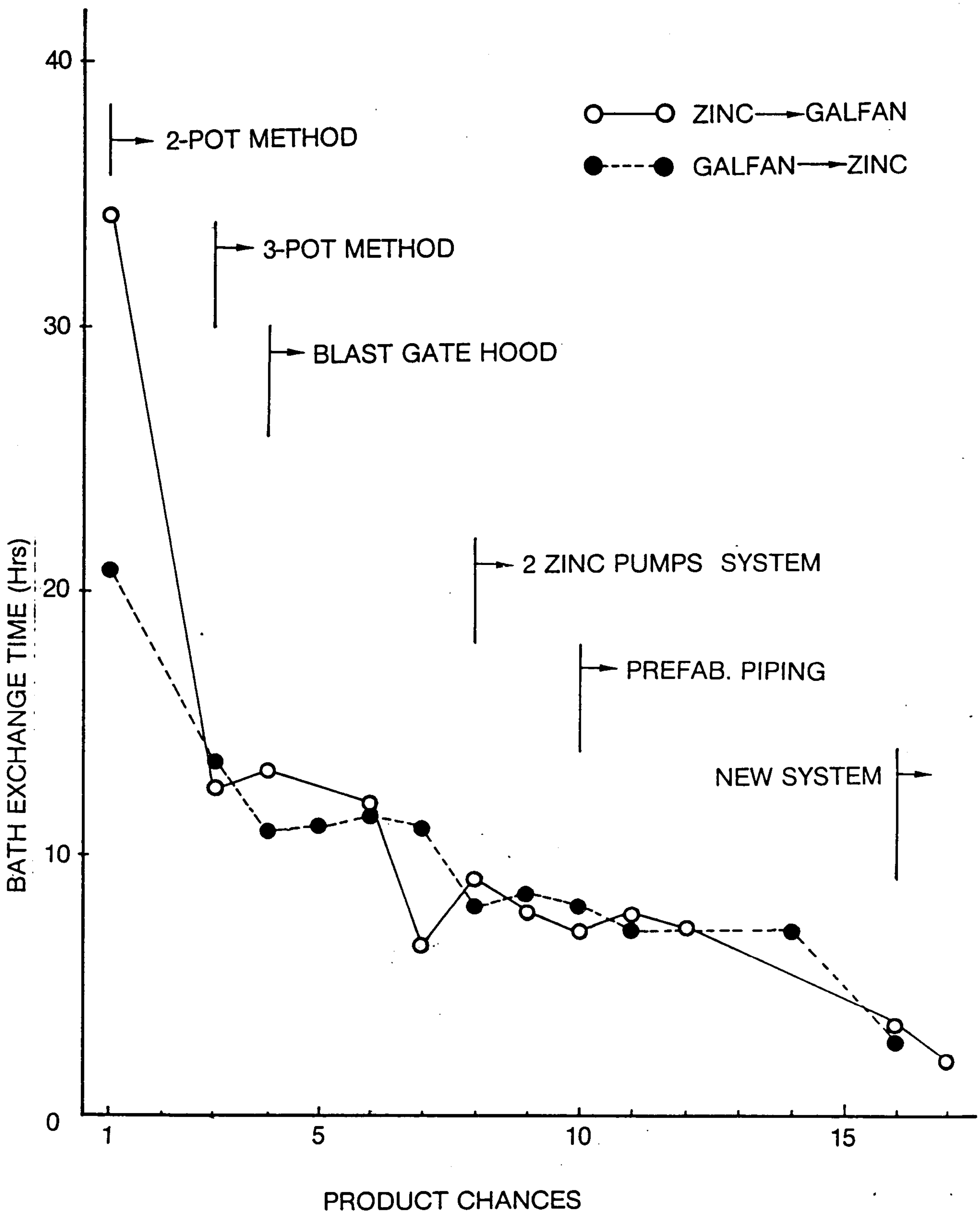


Fig. 1 Bath Exchange Time and Points of Modification

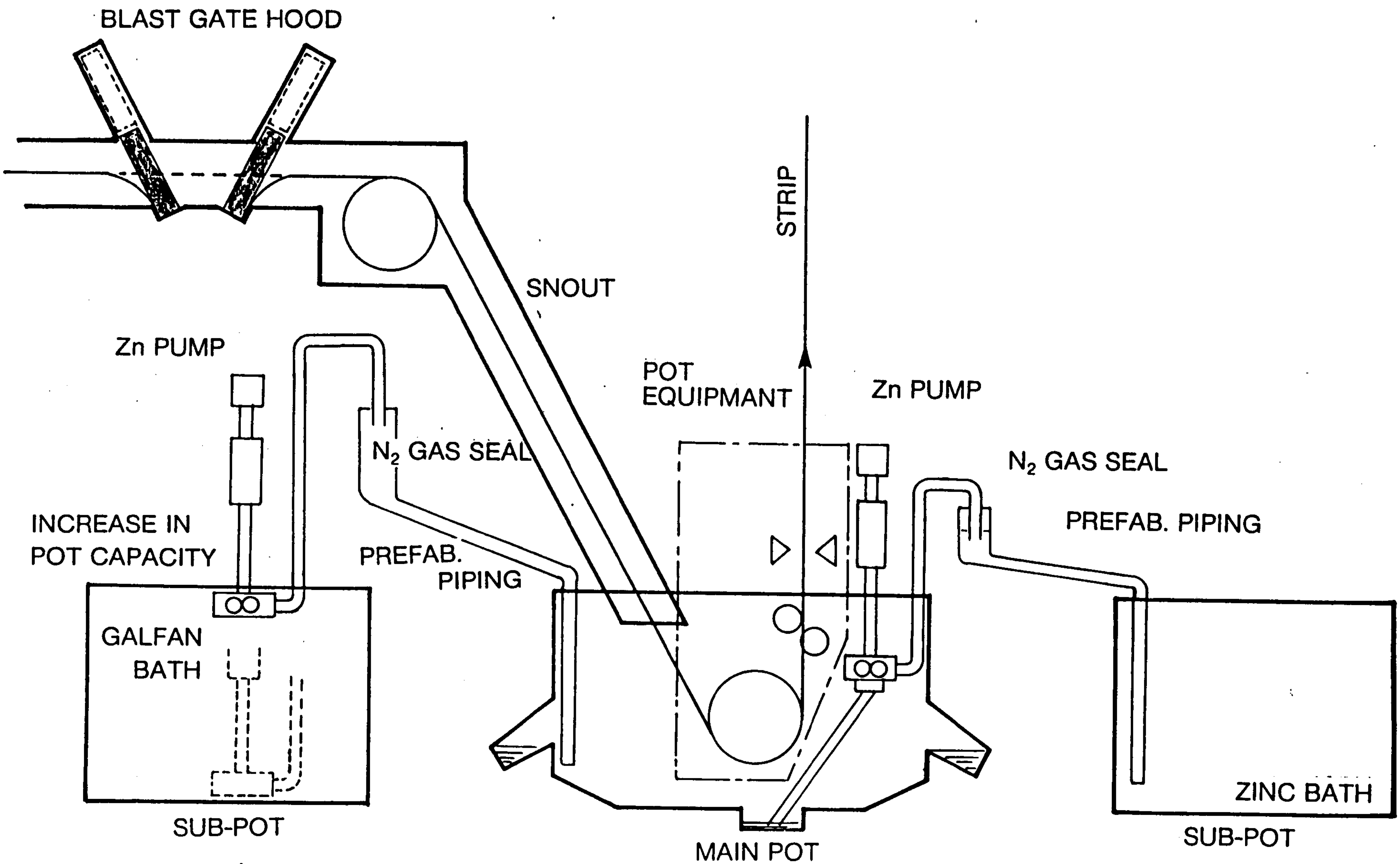
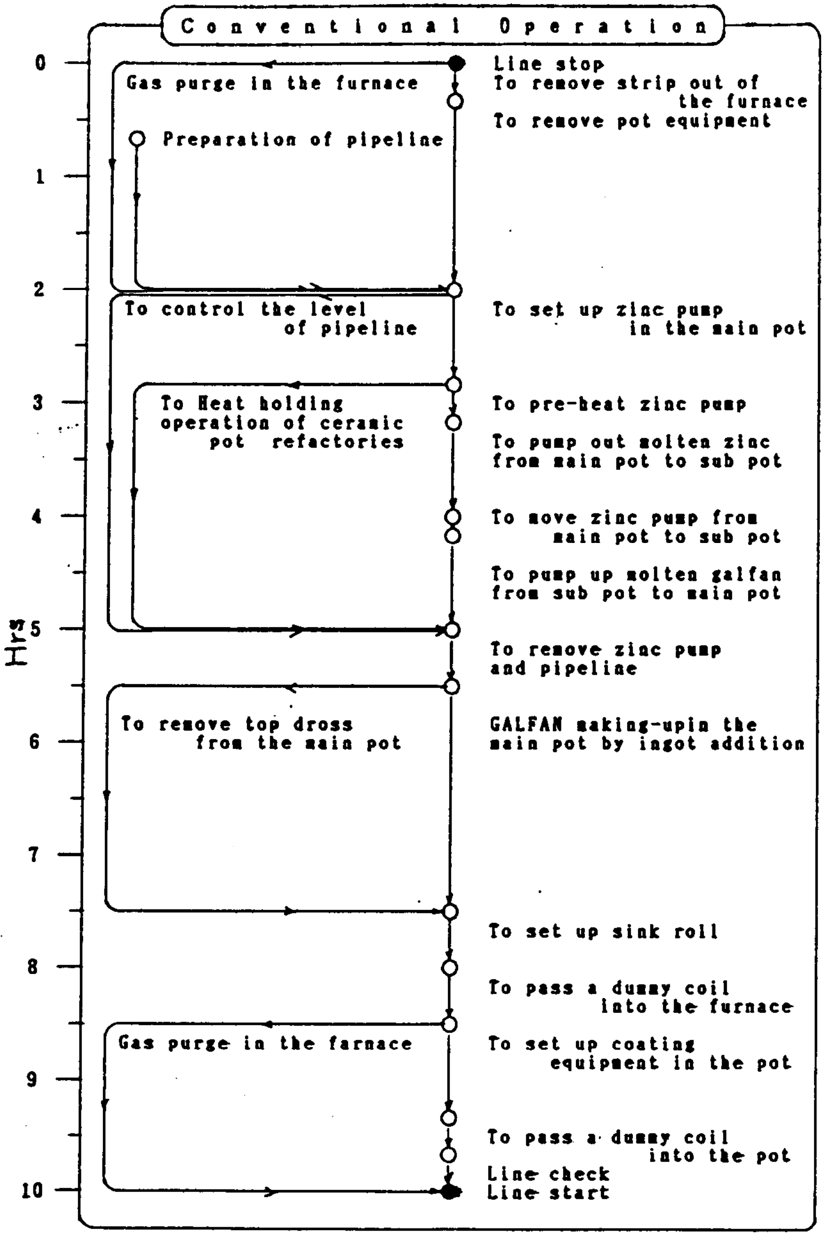
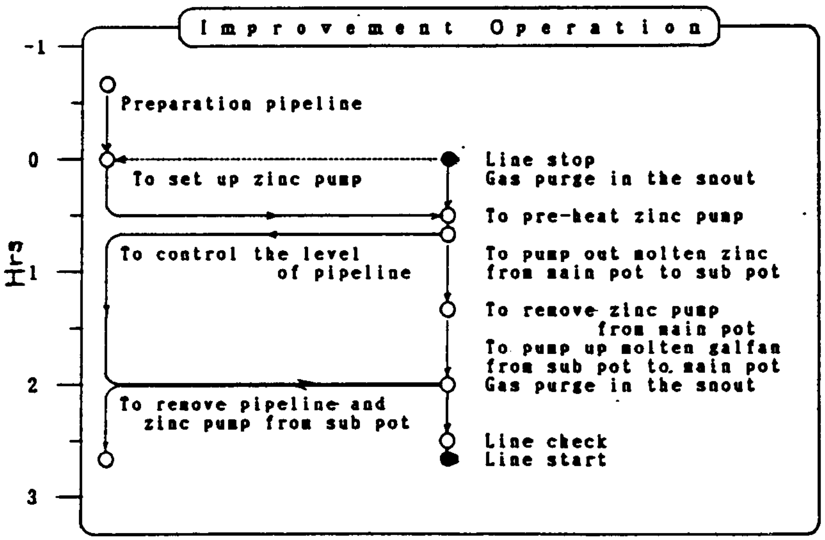


Fig. 2 Schematic Diagram of Bath Exchange Unit



Improvement

1. Shortening of gas purge time.
2. Firm fixation of the pump for pumping up the molten bath metal in the main pot.
3. Omission of heat-holding operation of ceramic pot refractories.
4. The adoption of Pre-fab pipeline.
5. Omission of GALFAN ingot make up operation at the main pot.
6. To decrease the generation quantity of the top dross.



Fig－3 Conventional and Improvement Operation of the Bath Exchange.

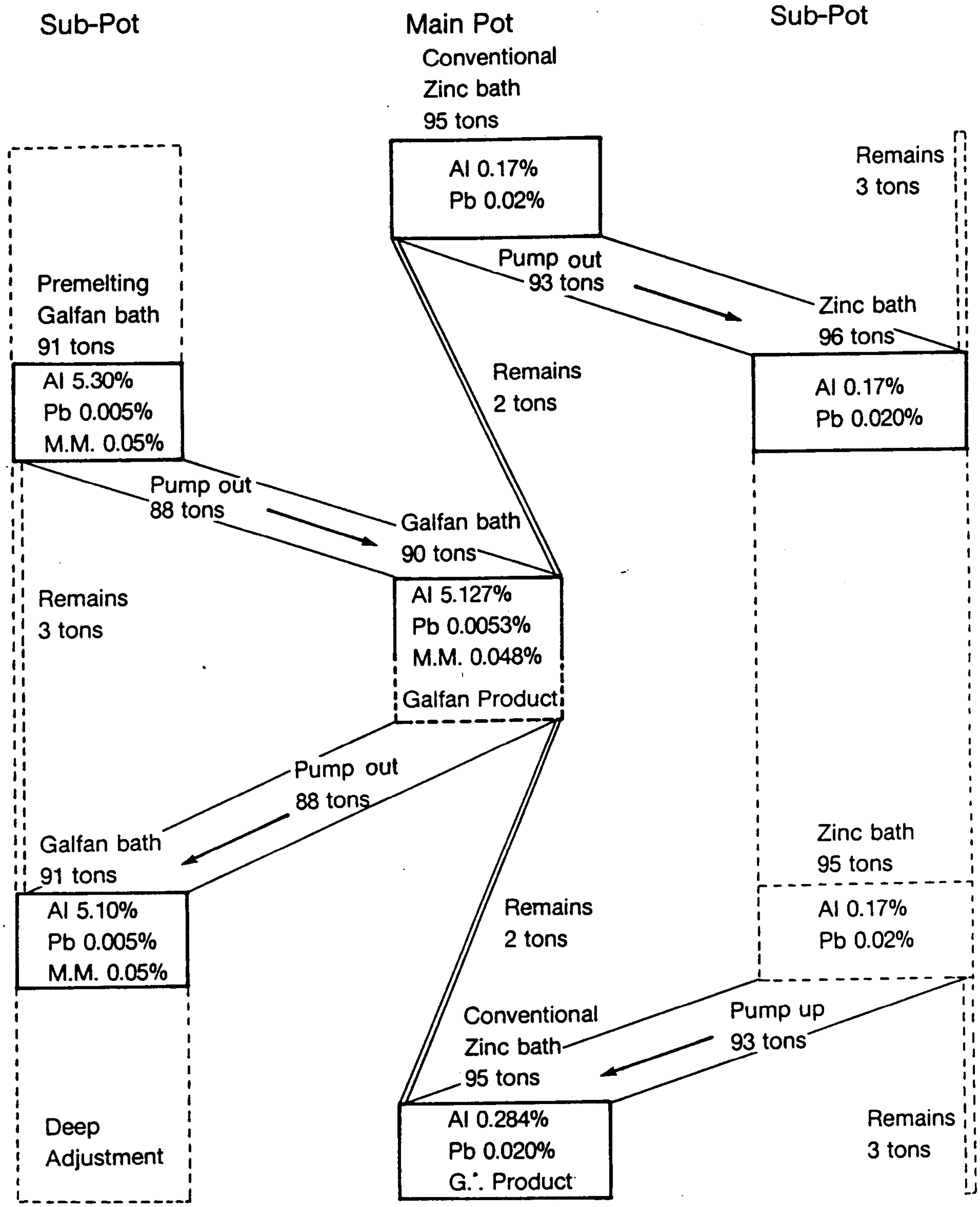


Fig. 4 Schema of Bath Balance

ILZRO PROJECT ZM 285 : GALFAN

ATMOSPHERIC EXPOSURE PROGRAMS

I. GALFAN FROM PILOT LINE TRIALS (1980).

II. GALFAN OF FIRST ZIEGLER TRIALS (1982)

1. EVALUATION AFTER 6 MONTHS, 1 AND 2 YEARS
2. REMAINING SETS IN

   LIÈGE : 1 OOSTENDE 1 : 2

   EUPEN : 3 OOSTENDE 2 : 2

III. LONG TERM ATMOSPHERIC EXPOSURE PROGRAM (1984)

1. COMPARATIVE AND QUANTITATIVE STUDY OF GALVANIZED, GALFAN AND GALVALUME
2. MORE THAN 1000 SAMPLES ARE EXPOSED IN RURAL, INDUSTRIAL, MARINE AND SEVERE MARINE ATMOSPHERES.
3. GALFAN FROM

   FABRIQUE DE FER DE MAUBEUGE

   HOESCH STAHL

   NISSHIN STEEL (1985)

   PHENIX WORKS

   ZIEGLER

TEST PROGRAM FOR EXPOSURE TESTS ON SITE.

1981	LIEGE URBAN	EUPEN RURAL	OSTENDE I SEVERE MARINE	OSTENDE II MARINE
COATED STEEL SHEET				
GALFAN-PILOT LINE TRIAL	X	X	X	X
HOT DIP GALVANIZED	X	X	X	X
GALVALUME (BETHLEHEM)	X	X	X	X
ALUMINIZED	X	X	X	X
1982				
1ST ZIEGLER TRIAL	X	X	X	X
1983				
2ND ZIEGLER TRIAL	X	X	X	X
1ST YODOGAWA TRIAL	X			
1ST HOESCH TRIAL	X			
1984				
PROGRAM				

CORROSION IN SOIL

CHARACTERISATION OF THE DIFFERENT SPECIMENS.

COATING	ORIGIN	COATING WEIGHT GR/M^2	CHROMATED
GALVANIZED	P.W.	275	-
GAL	USINOR	275	X
GALFAN	ZIEGLER	275	-
GALFAN	ZIEGLER	350	X
GALVALUME	BETHLEHEM STEEL	150	-
ALUZINC	ARBED	150	X
ALUMINIZED	ZIEGLER	100	

COATING TESTED UNDER THE BUSSES

COATING	THICKNESS µM	DURATION OF THE TEST (YEARS) PAINTED	UNPAINTED
ELECTROZINC	10	2	2
GALFAN	15	2	2-4
GALFAN	20	2	2
GALFAN	5	-	2
GALVALUME	17	2	2-4
GALVANNEALED	10	2	2
ZINCROMETAL	16	2	2
ZINCROX	17	2	2
ZINC-NICKEL (ELECTRO)	10	2	2

UNDER BUSSES CORROSION OF PAINTED SAMPLES

- PAINTED GALVALUME AND GALFAN SAMPLES SHOW A HIGH CORROSION RESISTANCE.

- AS CONCERN THE CUT EDGES GALVALUME IS MORE SENSITIVE THAN GALFAN.

- IN THE ORDER OF MERIT AS IN THE CASE OF UNPAINTED SAMPLES THE ALUMINIUM ZINC COATINGS WERE FOLLOWED BY GALVANNEALED.

- ON THE PAINTED ZINC-Ni COATING IT APPEARS SOME BLISTERS (SMALL IN DIMENSIONS).

- PAINTED HOT DIP GALVANIZED AND ELECTROZINC SHOW LARGE BLISTERS.

- ZINCROMETAL SAMPLES HAD PRACTICALLY NO BLISTERS. BUT AT THE IMPACT OF GRAVELS WHERE THE PAINT LAYER WAS DAMAGED RED SPOTS DEVELOPED IMMEDIATELY.

DARK GRAY PATINA PREVENTION

- 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 : $NiSO_4$ 25 G/L
NaH_2PO_2 25 G/L
$CH_3CHOHCOOH$ (85%) - LACTIC ACID
P_H = 4.5 (NH_4OH)
T = 98°C

THICKNESS : $\simeq$ 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

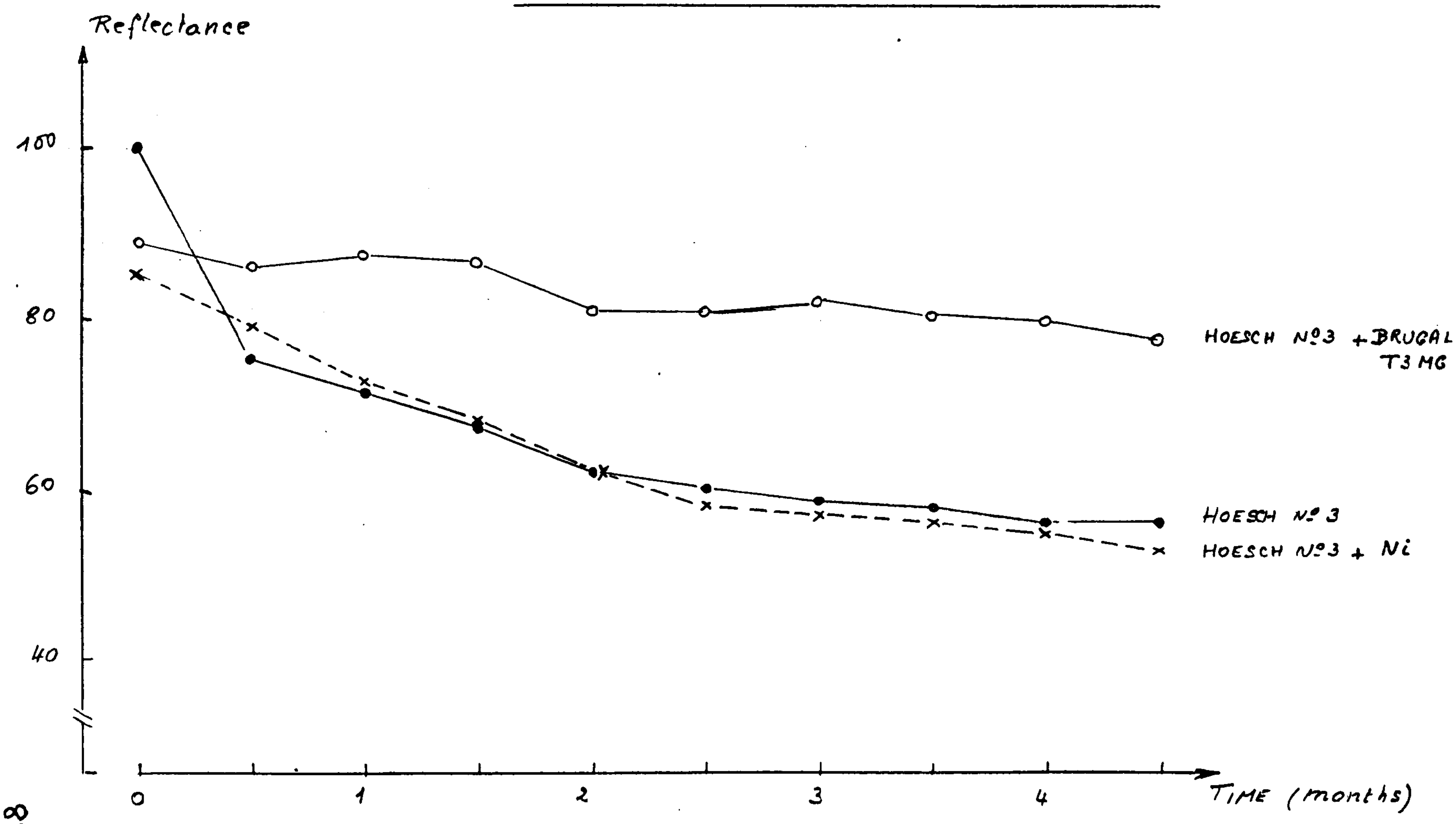
THICKNESS : $\simeq$ 1µ

RESIDUAL REFLECTANCE (%) OF INDUSTRIAL GALFANIZED SHEET AFTER ATMOSPHERIC EXPOSURE (URBAN SITE - LIEGE)

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

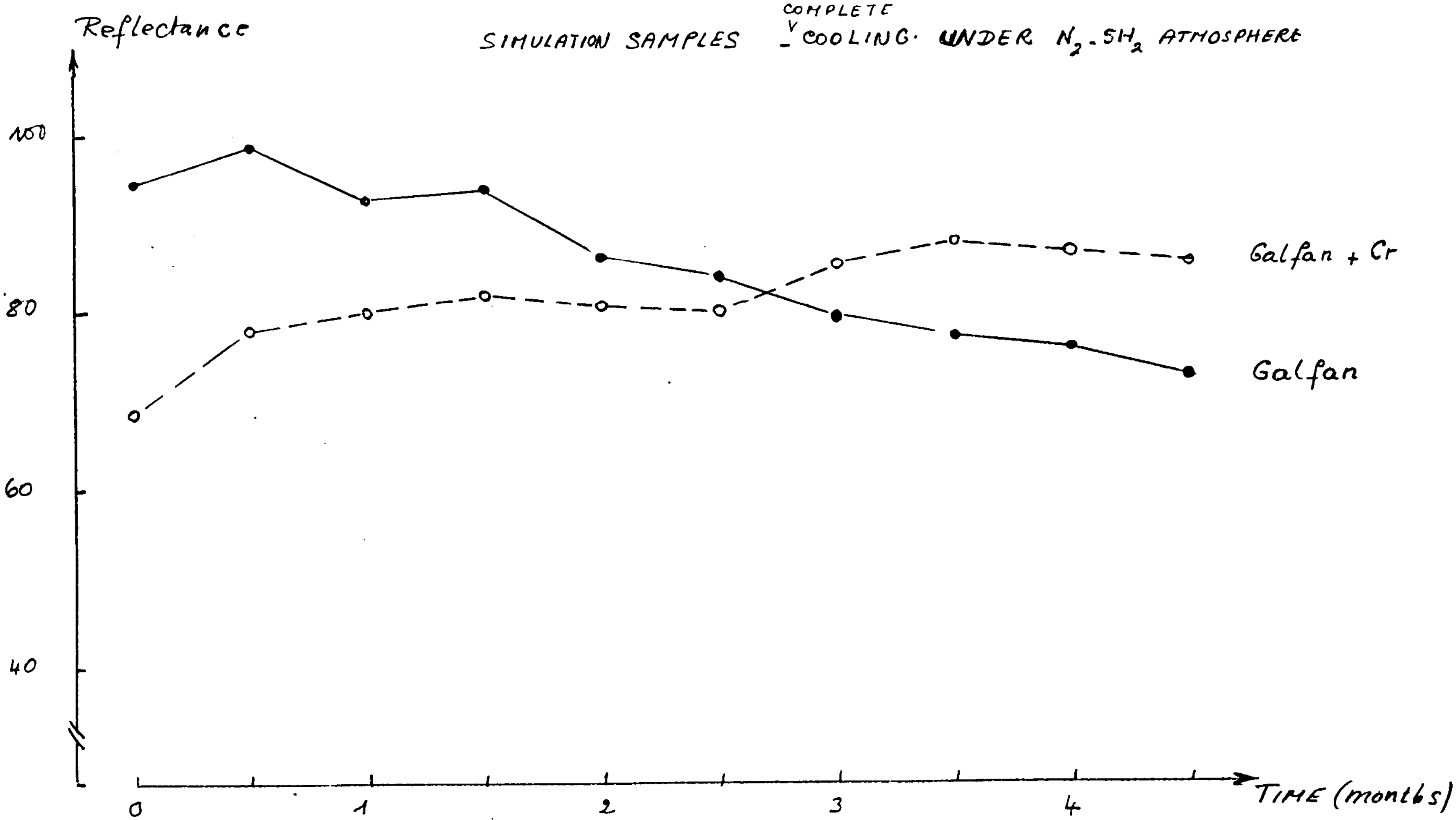
POST-TREATMENT	EXPOSURE TIME	
	2 MONTHS	4 MONTHS
NONE	62%	56%
Ni ELECTROLESS PLATING	73%	64%
BRUGAL T3 MG (50%)	90%	90%

LIGHT REFLECTANCE MEASUREMENTS



LIGHT RETLECTANCE ΓΙΕΑSUREMENTS

SIMULATION SAMPLES – COMPLETE COOLING · UNDER N_2-5H_2 ATMOSPHERE



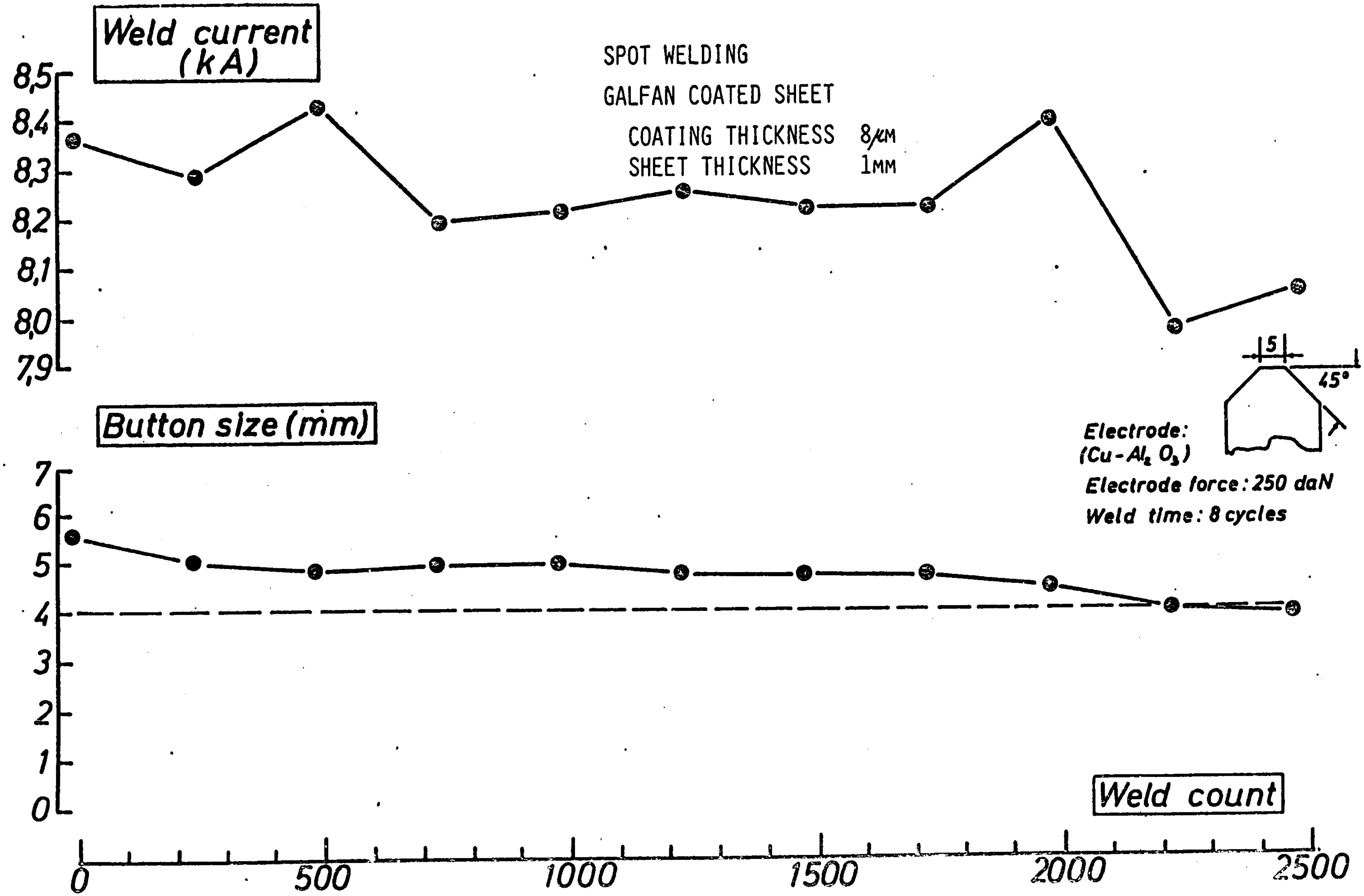


FIG.V.19_Welding of 95% Zn 5% Al coated steel with truncated electrodes (n°19)

CRM 06273 DL

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GALFANIZING OF STRIP

WITH THE COOK-NORTEMAN PROCESS

MINI-LINE TRIALS AT CRM - SEPTEMBER 23-25, 1986

WHEELING-PITTSBURGH STEEL CORPORATION

ELECTROFLUXING PROCESS

= SINGLE DIP PROCESS

= APPLICATION OF A DIRECT CURRENT DURING THE FLUXING STEP

PROCESS SUITABLE FOR WIRE
STRIP

CHARACTERIZATION OF STEEL USED FOR THE MINI-LINE TRIALS

TYPE OF STEEL	SIZE	WEIGHT (KG)	TENSILE STRENGTH (PSI)	TENSILE STRENGTH (MPA)	ELONGATION (%)
INGOT-CQ	0.46 x 63.5MM	23	49,000	338	38
CONCAST-CQ	0.44 x 63.5MM	23	43,800	302	38
CONCAST-DQ-AK	0.47 x 63.5MM	46	43,500	300	41
INGOT-SQ-GRADE E	0.36 x 63.5MM	23	112,000	772	2
INGOT-SQ-GRADE E	0.42 x 63.5MM	23	114,900	792	25

LINE SPEED = 5M/MIN (16 FT/MIN)

1. DEGREASING WITH TRICHLORETHYLENE
   LENGTH = 0.5M
   IMMERSION TIME = 6SEC

2. DRYING WITH HOT AIR

3. PICKLING IN HYDROCHLORIC ACID
   T = 40-50°C - HCl 15% BY WEIGHT
   LENGTH = 0.75M
   IMMERSION TIME = 9 SEC

4. RINSING IN COLD WATER

5. ELECTROFLUXING

   Length = 0.4m

   Immersion time ≃ 5 sec

   Flux CRM II - 40° Bé - p_H ≃ 1

   T = 85°C

   Direct current (I=90 A - U = 4 Volts)

   Four vertical stainless steel electrodes

   - width = 100mm
   - height = 100/150mm

   Spacing of sheet from electrodes ≃ 10mm.

6. EVENTUAL WIPING OF FLUX IN EXCESS

   Rubber strickles

7. EVENTUAL ADDITIONAL DRYING OF FLUX

   Small flame burner

8. DRYING OF FLUX IN A TUBULAR FURNACE
   LENGTH = 1M
   FURNACE TEMPERATURE = 300-350°C
   DRYING TIME = 12 SEC.

9. GALVANIZING
   GALFAN BATH
   T = 450-455°C
   IMMERSION TIME = 5 SEC

10. NITROGEN EXIT DEVICE

11. AIR COOLING

CURRENT DENSITY X IMMERSION TIME = 80 $\frac{A.SEC}{DM^2}$ (A/DM^2) (SEC)

1 A X SEC = 1 CB.

96487 ARE NECESSARY TO DEPOSIT ONE EQUIVALENT GR.

OF METAL ($\frac{65.38}{2}$ G ZN)

$$80 \frac{A.SEC.}{DM^2} = 8000 \frac{CB}{M^2}$$

$$\longrightarrow \quad \frac{8000 \times \frac{65.38}{2}}{96487} \quad G/M^2$$

$$\longrightarrow \quad 2.71 \; G/M^2$$

THICKNESS OF ZN COATING = $\frac{2.71}{7.14} \simeq \underline{0.4\mu}$

DETERMINATION OF TOTAL CURRENT IN THE CASE OF INDUSTRIAL CONDITONS

WIDTH OF STRIP = 24" (61 CM)

LINE SPEED = 450 FT/MIN (137M/MIN)

IMMERSION LENGTH = 10 FT (3M)

IMMERSION TIME = 1.3 SEC

RELATION –> CURRENT DENSITY = 61.5 $\frac{A}{DM^2}$

USEFUL SURFACE OF ELECTRODES = 20 SQ.FT (185.9 DM^2)

TOTAL CURRENT = <u>11432</u> A

Centre de Recherches Métallurgiques

Centrum voor Research in de Metallurgie

DATE 27 October 1986.

GALFANIZING OF SHEET WITH THE COOK-NORTEMAN PROCESS
MINI-LINE TRIALS AT CRM - SEPTEMBER 23-25, 1986

I. Introduction

The development of the Galfan alloy for continuous galvanizing was initiated at CRM in 1979. The first industrial trial was made in 1981 at Ziegler (France). The processing of Galfan in continuous sheet galvanizing lines (Sendzimir process) did not require any fundamental changes to the process and is now in application in several lines in France, Japan, Germany, USA. The evaluation of the material produced by these galvanizers showed the superior corrosion resistance of Galfan compared to galvanized, but the coating proved also to be highly ductile allowing deep drawing and profiling without the spangle cracking which is typical for galvanized.

In the case of wire, trials were made in order to coat wires with Galfan after pickling and fluxing. Due to the reaction between the flux components (especially NH_4Cl) and the aluminium contained in the bath, it was not possible to use the conventional process (pickling, rinsing, fluxing in aqueous double salts solution, drying and galvanizing); several flux manufacturers (Dupont, Mitsui, Floridienne, Basf) developed special fluxes for Galfan but the results were not satisfactory and some coating defects remained : rough surface, black areas, embedded flux residues ... In a first step, the so-called double dip process was developed in the CRM laboratories and applied in 1983 at FICAL (France); in this process, the wire is first galvanized in a zinc bath after conventional fluxing; a second normal fluxing can then take place before immersion in the Galfan bath; at the exit of the bath, the wire passes through a gas exit device (N_2 box) in order to give a smooth surface to the coating.

For technical and economical reasons, it was judged essential to develop a single dip process for wires. Such a process, called "Electrofluxing process" was developed by CRM in 1985. The major characteristic of this process is the application of a direct-current during the fluxing step; a very thin layer of zinc is deposited on the steel (0.4 - 0.5 μ) together with a liquid layer having the composition of the flux. The first trials for wire were made in a plant of Technoarbed (Luxembourg).

2. Description of the trials

The trials performed for Wheeling-Pittsburgh aimed to coat a sheet with Galfan using the Cook-Norteman process which is used industrially since 1953.

The characterization of the six coils sent by Wheeling-Pittsburgh is given in table 1. Three of these coils were concast steel and two of them were in full-hard conditions (Grade E steel).

The description of the mini-line trials can be found in table 2. For the electrofluxing process, the sheet passes between four vertical stainless steel electrodes of 100 mm wide; two of them are located in the central part of the pot and their useful height is 100 mm; the two other electrodes have a useful height of 150 mm.

The aim of the trials was to obtain a sound coated product with high adherence and without bare spots. The electrofluxing process appeared to be suitable in the case of sheets. Five coils were coated with Galfan and the results appeared good. In fact, sheets coated in the best conditions showed a good adherence of the coating and no major defect.

The annealed steels being very soft some waves appeared along the edges due to mechanical and alignment problems in the mini-line (motion of cylinders); in spite of these waves, the surface aspect of the coating was quite good.

Without any wiping of the flux at the exit of the electrofluxing bath, there were too many ashes and flux residues at the inlet of the sheet; the emission of fumes was also too important.
First of all, a wiping device with rubber strickles reduced in a great extend the ashes and fumes formation. The ash formation was then estimated to 11 kg/ton. In addition to this wiping, a small flame burner was used in order to dry the flux before the sheet passes through the tubular furnace; the ash formation was then reduced to an estimate value of 2 kg/ton. Such a wiping and drying of the flux is achieved in fact on the Wheeling-Pittsburgh lines by using brushes and burners; therefore, the ash formation should not be a great problem in a production trial.

Due to the low speed line (5 m/min.), the effect of the nitrogen exit was not very clear; moreover, the wiping of the coating using nitrogen or air-knives was not possible; however, in industrial scale, the wiping of the coating (superheated steam, air, nitrogen) should be very easy due to the high fluidity of Galfan.

Details on the determination of current density for the electrofluxing step as well as calculations based on data of the Wheeling-Pittsburgh lines (speed-dimensions of fluxing bath - width of strip) are annexed to this report.

A. DAVIN B. RENAUX

Table 1 - CHARACTERIZATION OF STEEL USED FOR THE MINI-LINE TRIALS

Coil No.	Type of Steel	Size	Weight (Lbs)	Tensile Strength (pSi)	A (%)
A 83224-C	Ingot-CQ	0.018" x 2.5"	50	49000	38
A 83125-C	Concast-CQ	0.0175" x 2.5"	50	43800	38
Y 74911-B	Concast-DQ-AK	0.0185" x 2.5"	50	43500	41
Y 74911-C	Concast-DQ-AK	0.0185" x 2.5"	50	43500	41
YR-3369-C	Ingot-SQ-Grade E	0.0142" x 2.5"	50	112000	2
YR-3365-C	Ingot-SQ-Grade E	0.0165" x 2.5"	50	114900	25

Table 2 - DESCRIPTION OF THE MINI-LINE TRIALS

- Line speed = 5 m/min. (16 ft/min.)
- Degreasing with trichlorethylene
  Length = 0.5 m
  Immersion time = 6 sec.
- Drying with hot air
- Pickling in hydrochloric acid (T = 40-50°C - 15% by weight)
  Length = 0.75 m - Immersion time = 9 sec.
- Rinsing in cold water
- Electrofluxing bath
  Length of immersion = 0.4 m
  Immersion time ≙ 5 sec.
  Flux CRM II - T = 85°C - 40°Bé - pH≃1
  Direct current (I = 90 Amps - U = 4 Volts)
  Four vertical stainless steel electrodes (width = 100 mm)
  Spacing of sheet from electrode ≙ 10 mm
- Eventual wiping of flux in excess
- Drying of flux in a tubular furnace :
  Length = 1 m
  Furnace temperature = 300 - 350°C
  Drying time = 12 sec.
- Galvanizing : Galfan bath - T = 450 - 455°C
  Immersion time = 5 sec.
- Nitrogen exit device
- Air cooling

Annex 1 - RELATION BETWEEN CURRENT DENSITY AND IMMERSION TIME

In order to have a good zinc coating after electrofluxing the following relation must be obeyed.

$$\underset{(A/dm^2)}{\text{Current density}} \times \underset{(sec.)}{\text{Immersion time}} = 80 \frac{A.sec.}{dm^2}$$

$$1\ dm^2 = 1/100\ m^2 = 0.1076\ sq.ft.$$

$$I\ (A) = \frac{q\ (Cb)}{t\ (sec.)} \longrightarrow 1\ A \times sec. = 1\ Cb\ \text{(coulomb)}$$

Faraday's law : 96487 Cb are necessary to deposit one equivalent-gr. of metal.

$$Zn^{2+} + \underline{2}\ e^- \longrightarrow Zn$$

Atomic weight of Zinc = 65.38 gr

96487 Cb to deposit $\frac{65.38}{2} = 32.69$ g. Zn

$$80 \frac{A.sec.}{dm^2} = 80 \frac{Cb}{dm^2} = 8000 \frac{Cb}{m^2}$$

$$8000 \frac{Cb}{m^2} \longrightarrow \frac{8000 \times 32.69}{96487} \frac{g}{m^2}$$

$$\longrightarrow \underline{2.71 \frac{g}{m^2}}$$

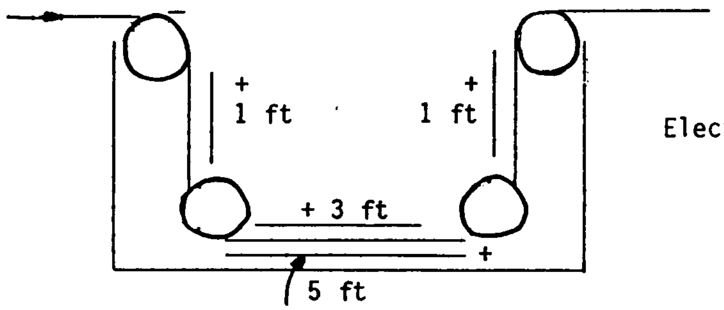
Thickness of Zn coating = $\frac{2.71}{7.14} \cong \underline{0.4\mu}$

1μ = 1 micron = 0.03937 mil = 0.0000394 inches

7.14 = density of Zn (g/cm^3)

$$\begin{cases} 1\ cm^3 = 10^{-6} m^3 \\ 10^{-6} m = 1\mu \end{cases}$$

Annex 2 - DETERMINATION OF THE TOTAL CURRENT IN THE CASE OF AN INDUSTRIAL RUN - Data for Wheeling-Pittsburgh line



Electrofluxing bath

Width of strip = 24" = 6.1 dm

$$(1 \text{ inch} = 25.4 \text{ mm} = \frac{25.4}{100} \text{ dm}$$

Speed = 450 ft/min.

= 450 x 0.3048 m/min.

= 137 m/min. = 1370 dm/min.

Immersion length = 10 ft

Immersion time $= \frac{10}{450} \times 60 = 1.3$ sec.

$$\text{Current density} \times \text{Immersion time} = 80 \frac{\text{A.sec.}}{\text{dm}^2}$$

$$\text{Current density} = \frac{80}{1.3} = \boxed{61.5 \frac{\text{A}}{\text{dm}^2}} = 571.6 \frac{\text{A}}{\text{sq.ft}}$$

$$\text{Useful surface of electrodes} = \underbrace{(1+1+3+5) \times 0.3048 \times 10}_{\text{total length in dm}} \times \underbrace{6.1}_{\substack{\text{width in dm} \\ \text{(= width of strip)}}}$$

$$= 185.9 \text{ dm}^2$$

$$= \frac{185.9}{100} \times 10.76 = \underline{20 \text{ sq.ft}}$$

Total current = 61.5 x 185.9 = <u>11432 A</u>

Three parameters must be controlled :

1. Level of flux (because of drag-out)
   $\Rightarrow$ need to fill liquid flux (complete composition)

2. pH of flux $\Rightarrow$ need to add HCl

3. Density of flux (°Bé)
   $\longrightarrow$ need to add $ZnCl_2$ solid because of Zn deposit.
   That zinc is not entirely lost because it is melted in the galfan pot.

Quantity of zinc deposited on the sheet in <u>one hour</u> :

- Thickness of Zn $= \frac{2.71}{7.14} = 0.38\mu$ <u>on each side</u>

  450 ft/min. x $\underbrace{60}_{1\ \text{hour}}$ x $\frac{24}{12} = 54\,000$ sq.ft.

  Weight of Zn $= \underbrace{\frac{54\,000}{10.76}}_{m^2} \times \underbrace{2.71 \times 2}_{g/m^2\ 2\text{sides}} = 27\,200$ g

  $= 27.2$ kg

  $= 27.2 \times 2.205$

  That Zinc comes into $\Leftarrow$ $\cong$ **60 Lb**

Atomic weight of $ZnCl_2 = 65.38 + 2 \times 35.46 = 136.3$ gr.

Weight of $ZnCl_2 = \frac{27\,200}{65.38} \times 136.3 \simeq 56.7$ kg $ZnCl_2$

$\simeq$ <u>125 Lb</u> $ZnCl_2$

British Steel Corporation
Welsh Laboratory
Port Talbot

14.10.86

Galfan Meeting
November 12th, 1986

ATMOSPHERIC CORROSION RESISTANCE OF GALFAN COMPARED WITH HOT DIP GALVANISED STEEL

D. Jones, British Steel Corporation
Welsh Laboratory

1. INTRODUCTION

In order to compare the corrosion resistance of Galfan with that of conventional Hot Dip Galvanised Steel (HDG), two exterior exposure test programmes were set up using respectively Galfan produced on the Pilot Line at CRM and Galfan manufactured during the initial production trial at Ziegler.

The initial test programme involving the CRM Galfan has completed 5 years exposure at 2 sites whereas the second exercise is approaching completion of 4 years at 3 sites. This note reports on the examination of the panels at the end of these test periods.

2. DETAILS OF TEST PROGRAMME

2.1 Test Programme No.1

In these tests, Galfan produced on the Pilot Line at CRM was compared with non-passivated Hot Dip Galvanised Steel at two sites - Morfa Bank and Research Centre. Morfa Bank is classified as a severe marine/industrial site. It is located close to the Coke Oven battery at BSC Port Talbot Works in a coastal situation which is only 10 metres from the high water mark, and as such the environment is very aggressive. Research Centre is classified as urban, moderate industrial although it is situated only 5km from the sea.

Test samples consist of flat panels (6"x4") to which small sections are attached by means of spot welds and rivets (Aluminium rivets). Edges were left unprotected. Panels were inclined at 45^{o} facing due South.

2.2 Test Programme No.2

The Galfan used in this exercise was from coils #1,4,6&10 produced in Ziegler Campaign #1, which cover a range of coating weights. For comparison, chromated and non-chromated HDG was used.

Two different designs of test panels were employed for these tests - a profiled WA6 panel with exposed bottom edge to simulate cladding applications and a variable radius mandrel bend. The latter is deformed 90^{o} around a former with a variable bend radius ranging in descrete increments from 1mm to 4mm.

In addition to the Morfa Bank and Research Centre sites, panels were also exposed at Burry Port which has an estuarine environment.

3. RESULTS AND DISCUSSION

A summary of the examination of the panels is given in Tables 1 to 7 and photographs showing the panels are attached.

It is clear from the evaluation of the CRM Galfan that Galfan does possess superior atmospheric corrosion resistance to that of conventional HDG in specific environments. Although the materials are not directly comparable because the CRM Galfan has a thicker coating, nevertheless after 5 years exposure at the Morfa Bank, in a very aggressive marine/industrial environment, Galfan was in reasonably good condition whereas the HDG was heavily corroded to the extent that it had perforated. Whilst the HDG was not at such an advance stage of corrosion at the less corrosive Research Centre site, there was still extensive red rust creep from the cut edges whereas there was no red rust on the Galfan panels. It will be interesting to see how these Galfan panels perform over the next few years.

The second series of corrosion testing involving the Ziegler Campaign #1 material is not as advanced, ranging in duration from 44 months to 4 years depending on the site. It does, however, cover a range of coating weights which hopefully with time will yield more information than the initial test programme. At this stage, it is only at the Morfa Bank site are there any signs of marked deterioration. It is an interesting feature of this site that the groundward facing aspect normally corrodes at a greater rate than the skyward face[1], and in this case, where panels have perforated it has been due to corrosion of the groundward face. Of the profiled WA6 panels, only the chromated HDG has perforated although the Galfan #1 and non-chromated HDG were extensively red rusted on the groundward face. The Galfan #6 was also showing pinhole red rusting whereas there was no red rust on the Galfan samples with the thicker coatings. A similar pattern has emerged with the variable bend panels although in this case it was the Galfan Coil #1 sample which had perforated. Allowing for coating weight differences, the indications are that the Ziegler Galfan is performing better than conventional HDG in this environment.

At the other sites, there was no evidence of red rust on any of the Galfan samples, although there were a few spots of red rust on the HDG panels at the Research Centre site. In these less corrosive environments, the tests are, however, not sufficiently advanced enough to allow any meaningful comparisons to be made, but the performance of these panels over the next few years (which are likely to the critical years) will be followed with interest.

The formation of the grey patina in Galfan has been a major discussion item in Galfan Licensees' meetings, and it is interesting to note the different behaviour in polluted and non-polluted atmospheres. As reported earlier, the Galfan panels darkened very rapidly (within a few weeks) at the Morfa Bank and Research Centre sites, whereas at the Burry Port site, which is in a largely non-polluted area, the development of this grey patina was not so pronounced, and after 4 years test the Galfan panels were only slightly darker than the weathered HDG samples.

Further tests are planned using fast cooled Galfan from the latest production campaigns to compare with the present generation of hot dip zinc coated steels.

This work forms part of a larger exercise being carried out by British Steel Corporation comparing the performance of a range of coated steels. Galvalume is included in these tests and it is interesting to note that all the Galvalume panels are in very good condition at the same stage of the evaluation programme considered in this report.

REFERENCE

1. "An Assessment of the Atmospheric Corrosion Resistance of Hot Dipped Galvanised Steel after 5 Years Exposure" R.M. Evans, BSC Open Report SM/569/C.

Author: D. Jones

Departmental Manager
Dr. K.G. Lewis
Coated Products Technology

DJ/KLT

TABLE 1

SURFACE EXAMINATION OF HDG & CRM GALFAN AFTER 5 YEARS EXPOSURE AT THE MORFA BANK AND RESEARCH CENTRE SITES

Corrosion Site	Code	Material Identity	Coating Weight Exposed Face (g/m^2)	Examination
Morfa Bank	M1	Galfan - CRM Pilot Line	183	Extensive darkening of the surface. No sign of red rust, on either face.
	M5	HDG Non-Passivated	128	100% red rust. Steel base perforated.
Research Centre	R1	Galfan - CRM Pilot Line	183	Surface darkened. No evidence of red rust.
	R5	HDG Non-Passivated	128	Extensive red rust creep from cut-edges up to 25mm. Red rust around spot welds. No red rust around aluminium rivets.

TABLE 2

EXAMINATION OF GALFAN & HDG WA6 PANELS AFTER 46 MONTHS EXPOSURE AT MORFA BANK SITE

Corrosion Site	Exposure Time	Code	Material Identity	Coating Weight Exposed Face (g/m^2)	Examination
Morfa Bank	46 months	1M1	Galfan - Ziegler Coil 1	71	Surface darkened, but no signs of red rust on skyward face. Red rust on groundward face.
		4M1	Galfan - Ziegler Coil 4	164	Surface darkened. No signs of red rust on either face.
		6M1	Galfan - Ziegler Coil 6	127	Surface darkened. No red rust on skyward face. Pinholes of red rust on groundward face.
		10M1	Galfan - Ziegler Coil 10	211	Surface darkened. No signs of red rust on either face.
		HNM1	Non-Chromated HDG	121	Pinholes of red rust on skyward face with some spots of white rust. Extensive corrosion of groundward face.
		HM1	Chromated HDG	150	Panel perforated. Severe corrosion of groundward facing surface.

TABLE 3

EXAMINATION OF GALFAN & HDG WA6 PANELS AFTER 44 MONTHS EXPOSURE AT RESEARCH CENTRE SITE

Corrosion Site	Exposure Time	Code	Material Identity	Coating Weight Exposed Face (g/m^2)	Examination
Research Centre	44 months	1R1	Galfan - Ziegler Coil 1	71	Surface darkened, but generally in good condition. No red rust.
		4R1	Galfan - Ziegler Coil 4	164	As above.
		6R1	Galfan - Ziegler Coil 6	127	As above.
		10R1	Galfan - Ziegler Coil 10	211	As above.
		HR1	Chromated HDG HDG	150	Slight etching of the spangle finish. No evidence of red spot.
		HNR1	Non-Chromated HDG	[illegible]	A few pinholes of red rust, otherwise in reasonable condition.

TABLE 4

EXAMINATION OF GALFAN & HDG WA6 PANELS AFTER 4 YEARS EXPOSURE AT THE BURRY PORT SITE

Corrosion Site	Exposure Time	Code	Material Identity	Coating Weight Exposed Face (g/m^2)	Examination
Burry Port	48 months	1B2	Galfan - Ziegler Coil 1	71	Surface darkened, but not as much as at Morfa Bank and Research Centre sites. No red rust.
		4B1	Galfan - Ziegler Coil 4	164	As above.
		6B1	Galfan - Ziegler Coil 6	127	As above.
		10B1	Galfan - Ziegler Coil 10	211	As above. Panel had slightly "hammered" surface finish.
		HNB1	Non-Chromated HDG	102	Surface darkened, but no red rust.
		HB1	Chromated HDG	146	Etching of spangles, but no red rust.

TABLE 5

SURFACE EXAMINATION OF HDG & ZIEGLER GALFAN VARIABLE MANDREL BEND PANELS AFTER 46 MONTHS EXPOSURE AT THE MORFA BANK SITE

Corrosion Site	Exposure Time	Code	Material Identity	Coating Weight Exposed Face (g/m^2)	Examination
Morfa Bank	46 months	1M1	Galfan - Ziegler Coil 1	71	Localised perforation of top surface. Extensive red rusting of groundward facing surface.
		4M1	Galfan - Ziegler Coil 4	164	Surface darkened, but no red rust on either face.
		6M1	Galfan - Ziegler Coil 6	127	Top surface darkened, but red rust on groundward face.
		10M1	Galfan - Ziegler Coil 10	211	Surface darkened, but no red rust on either face.
		HNM1	Non-Chromated HDG	176	Slight red rusting of top surface. Extensive red rusting of groundward surface.
		HM1	Chromated HDG	154	Surface darkened. No red rust on skyward surface, extensive [illegible]ing of groundward face.

TABLE 6

SURFACE EXAMINATION OF HDG & ZIEGLER GALFAN VARIABLE MANDREL BEND PANELS AFTER 44 MONTHS EXPOSURE AT THE RESEARCH CENTRE SITE

Corrosion Site	Exposure Time	Code	Material Identity	Coating Weight Exposed Face (g/m^2)	Examination
Research Centre	44 months	1R1	Galfan - Ziegler Coil 1	71	Surface darkened. No red rust.
		4R1	Galfan - Ziegler Coil 4	164	Surface darkened, with some small white deposits. No red rust.
		6R1	Galfan - Ziegler Coil 6	127	As above.
		10R1	Galfan - Ziegler Coil 10	211	As above.
		HNR1	Non-Chromated HDG	102	Slight etching of spangle finish. Few small pinholes of red rust.
		HR1	Chromated HDG	146	Slight darkening of the surface. Few small pinholes of red rust.

TABLE 7

SURFACE EXAMINATION OF HDG & ZIEGLER GALFAN VARIABLE MANDREL BEND PANELS AFTER 48 MONTHS EXPOSURE AT THE BURRY PORT SITE

Corrosion Site	Exposure Time	Code	Material Identity	Coating Weight Exposed Face (g/m^2)	Examination
Burry Port	48 months	1B1	Galfan - Ziegler Coil 1	71	Slight darkening to a medium grey "hammered" finish. No red rust.
		4B1	Galfan - Ziegler Coil 4	164	Slight darkening to a medium grey. No red rust.
		6B1	Galfan - Ziegler Coil 6	127	As above.
		10B1	Galfan - Ziegler Coil 10	211	As above, but also showing "hammered" finish.
		HNB1	Non-Chromated HDG	176	Slight etching of spangle finish. No red rust.
		HB1	Chromated HDG	154	Slight darkening of surface. No red rust.

Figure 1 Surface Appearance of CRM Galfan & HDG after 5 Years Exposure at Morfa Bank Site

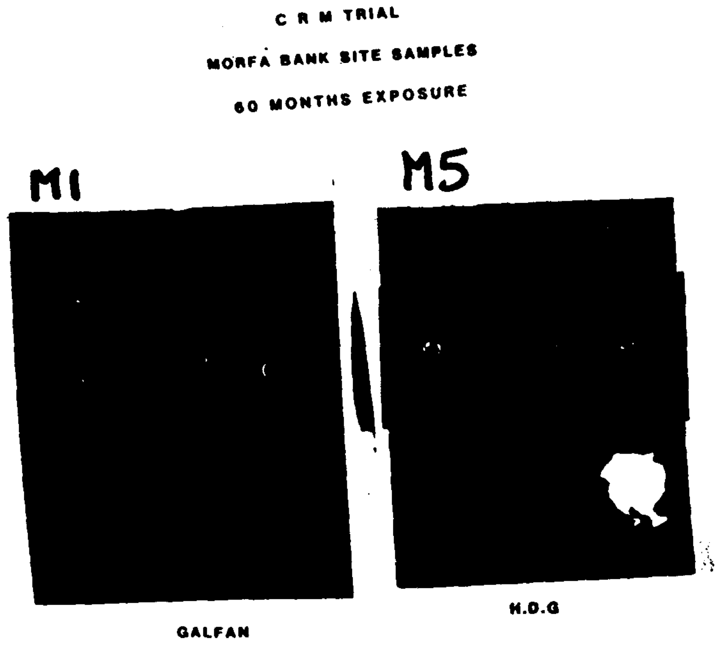


Figure 2 Surface Appearance of CRM Galfan & HDG after 5 Years Exposure at Research Centre Site

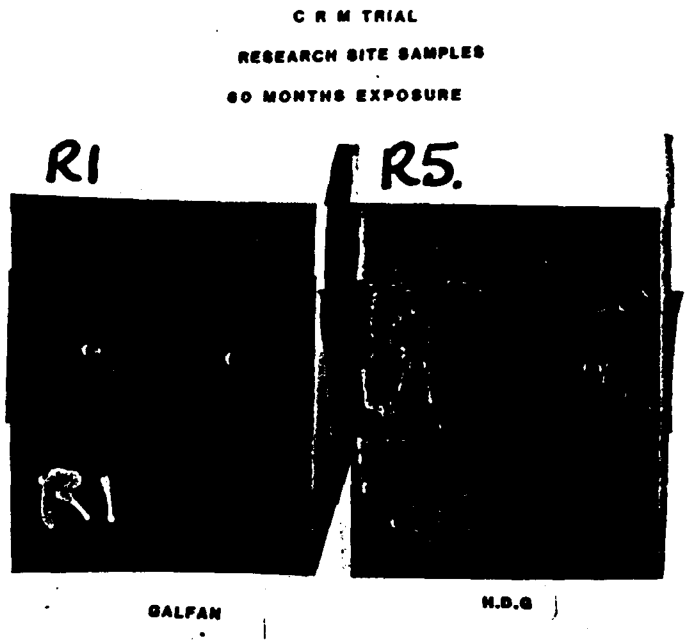


Figure 3 Surface Appearance of Ziegler Galfan & HDG Vari[illegible] [illegible]end Panels afte[illegible] 46 Months at Morfa Bank S[illegible]e

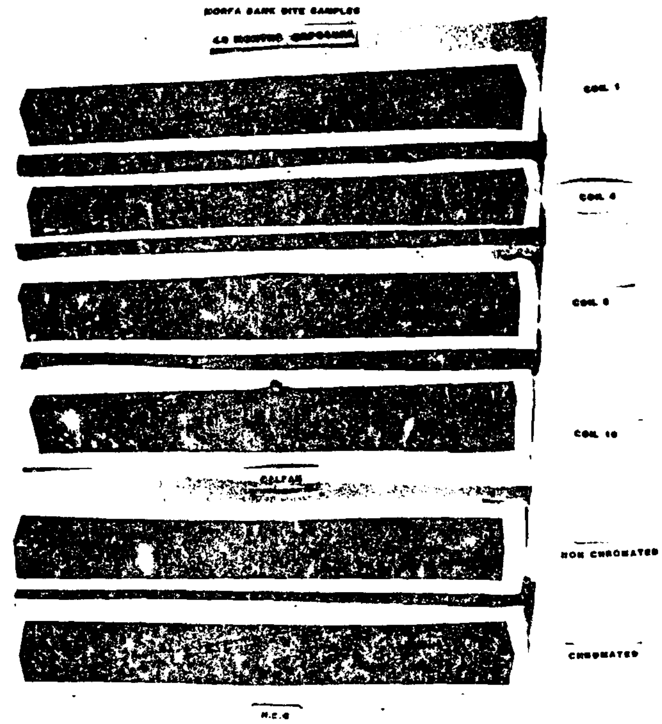
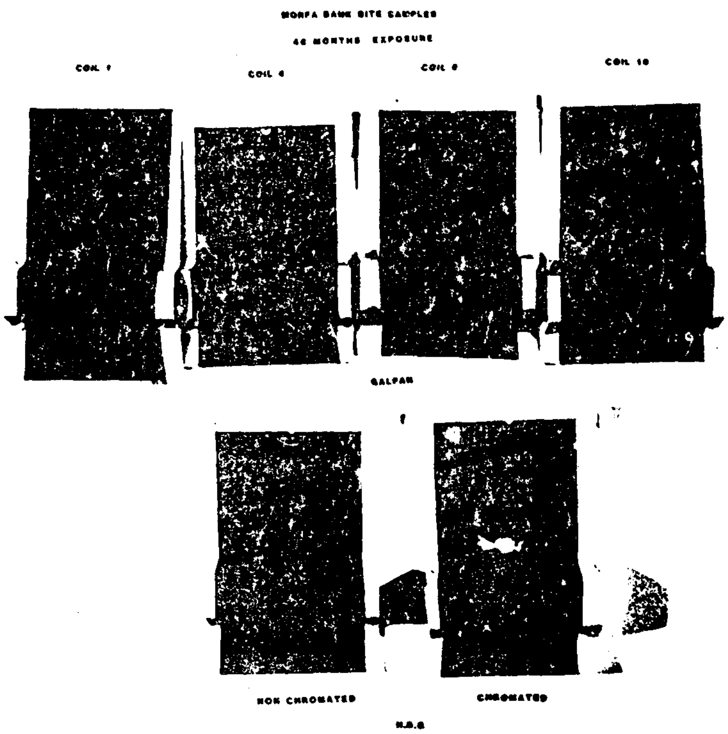


Figure 4 Surface Appearance of Ziegler Galfan & HDG WA6 Panels after 46 Months at Morfa Bank Site



after 44 Months at Research Centre Site

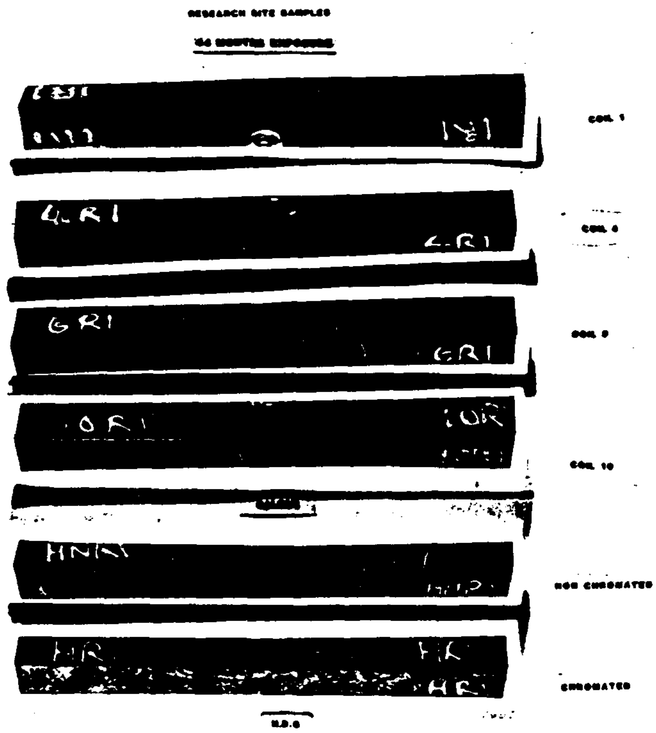


Figure 6 Surface Appearance of Ziegler Galfan & HDG WA6 Panels after 44 Months at Research Centre Site

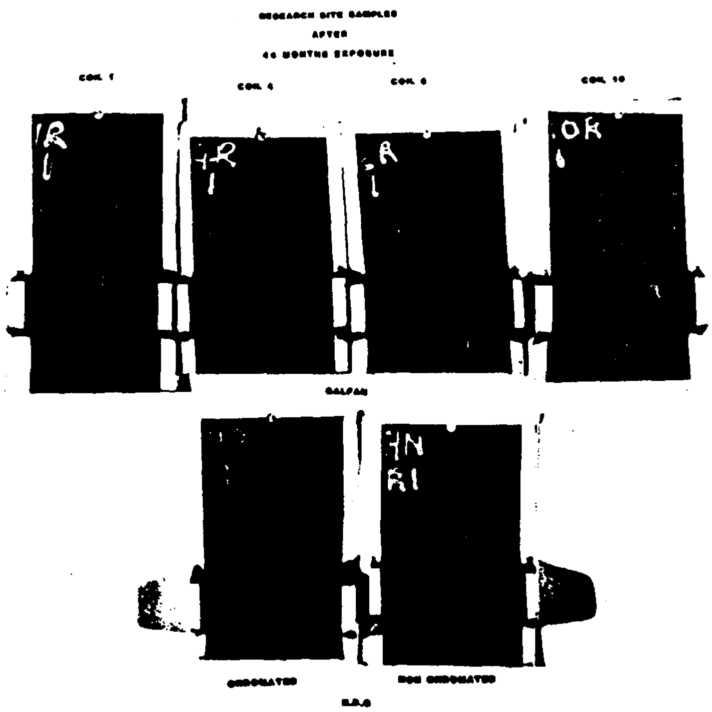


Figure 7 Surface Appearance of Ziegler Galfan & HDG Variable Bend Panels after 4 Years at Burry Port Site

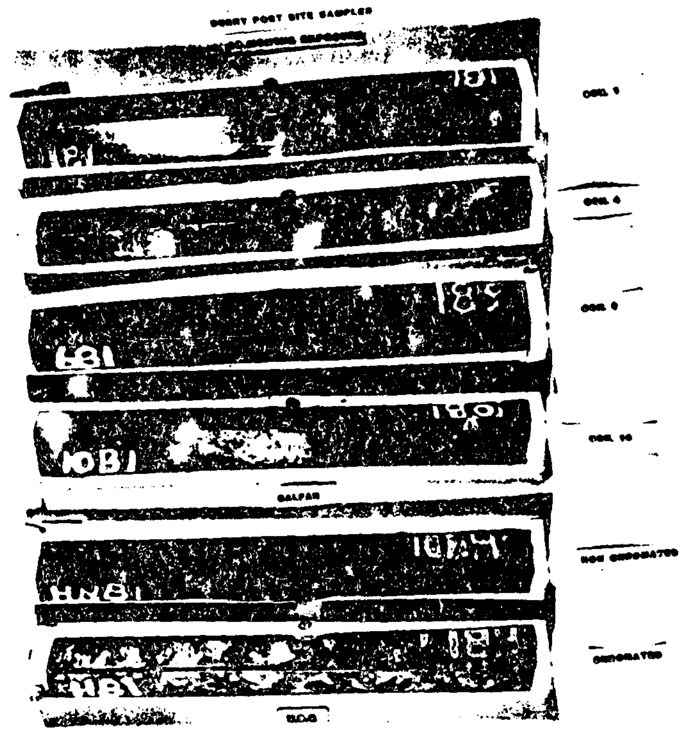
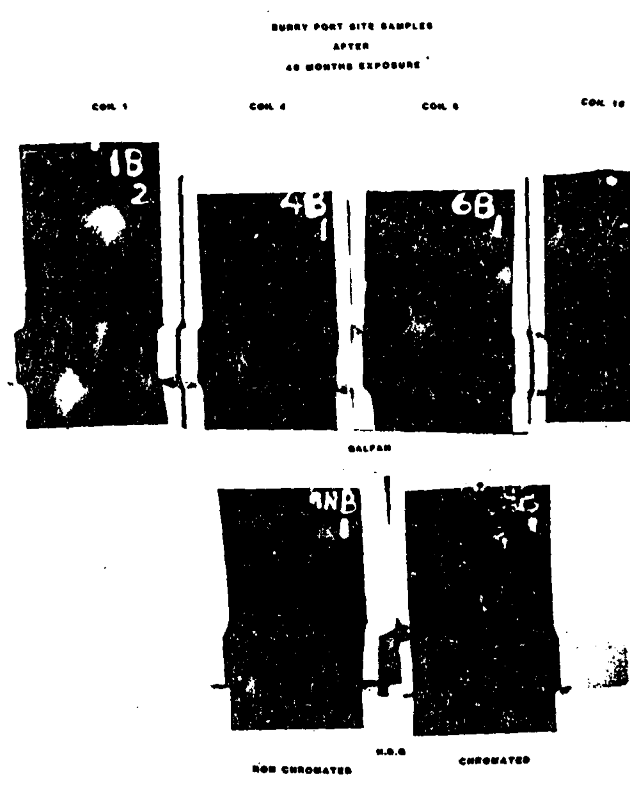


Figure 8 Surface Appearance of Ziegler Galfan & HDG WA6 Panels after 4 Years at Burry Port Site



INFLUENCE OF ALUMINUM CONTENT IN COATINGS ON THE PROPERTIES OF GALFAN

By Yusuke Hirose, Nisshin Steel Co., Ltd.

1. INTRODUCTION

In order to develop GALFAN, extensive investigation has been carried out on coating alloys around Zn-5%Al eutectic composition at CRM under ILZRO sponsorship since 1979. As the preliminary study indicated that the plain Zn-5%Al bath had a poor wettability toward steel substrate as compared with the conventional galvanizing bath, emphasis of the research has been placed on the improvement of the coating quality, i.e., suppression of bare spots, by adding third elements such as Li, Sn, Be, Ca, La, Ce, and so on, and the addition of La and Ce brought about a significant improvement on wettability of sheet steel with molten Zn-5%Al alloy. Detailed research on aluminum itself, however, which may have a noticeable influence around the Zn-5%Al eutectic composition on the properties of coatings, has not necessarily been accomplished.

To decide a exact bath composition for producing commercial Galfan, which was claimed with a certain range of aluminum content from hypoeutectic to hypereutectic, we, Nisshin Steel, have evaluated the coating properties within this range of aluminum based on a practical stand point of view.

This paper describes briefly the influence of aluminum content in the range of 4 to 7% in Zn-Al eutectic alloy on the surface appearance, the formability of the coating layer and the corrosion resistance based on the three-year exposure test as well as the accelerated corrosion test.

2. EXPERIMENTAL

2.1.Preparation of specimens

Specimens were produced on a NOF type continuous hot-dip coating pilot plant at Hanshin R&D Laboratories, Nisshin Steel. Three types of bath, Zn-4%Al, Zn-5%Al and Zn-7%Al alloy bath ,which contained 0.01% Mischmetall were used. Table 1 shows the chemical composition and the temperature of the bath. These alloys were coated on 0.3mm thick and 300mm wide pseudo-rimmed cold rolled steel coils. The coating weights ranging from 45g/m² to 190g/m² for one side were controlled by air-knife wiping. The strips just after being withdrawn from the bath were obliged to cool down with air so that the cooling rate could be maintained at about 20 °C/sec . The line was operated at the speed of 60m/min.

2.2.Characterization of specimens

The surface aspects of coated steel were examined visually and microscopically, particularly in terms of surface defects and the grainboundary dents.

Samples cut in size of 100 x 200 mm having various prescribed coating weights were subjected to both the accelerated corrosion test and outdoor exposure test. The specimens tested in the salt spray test and in the humidity cabinet test(50 °C, 98%RH), were inspected with their surface and the time to red-rusting was determined. The outdoor exposure specimens were mounted on a site of heavy industrial area in Amagasaki city (300m from the shoreline. near Osaka,Japan). Outdoor exposed specimens were examined by the microscope from the cross sectional view of the coating layer.

3.RESULTS

3.1. Surface appearance

Microstructure

Photo.1 shows the cross-sectional microstructure of the three types of coatings. In the Zn-4%Al coating being hypoeutectic composition, β-Zn as primary crystal, is surrounded by Zn-Al eutectic phase. At the exact eutectic composition, Zn-5%Al alloy has almost perfect eutectic structure, but there are some spherical primary zinc as shown in Photo.1(b). This deviation from the equilibrium diagram is due to the rapid solidification of coating layer. Under the high rate of cooling the eutectic point tends to deviate toward higher aluminum contents. Apparent eutectic composition is approximately at between 5.2%Al and 5.4%Al under the solidification rate of 20 °C/sec. Zn-7%Al alloy coating, hypereutectic, has aluminum-rich phase as a primary crystal.

Surface aspects

All of the strips coated with three different alloys showed good surface appearance having no bare spots. Zn-5%Al coated steel, however, exhibited mat grooves along the spangle boundary. This was due to the shrinkage at grainboundary surface which is inherent properties of eutectic alloys. The microstructures shown in Photo.1 are the ones in the sound portion of the coating layer. But at the grainboundary dents, the structure of Zn-5%Al coatings shows deep dent as represented in Photo.2. The depth of the dent is almost two thirds of the coating thickness. The dents can be seen on the Zn-4%Al and Zn-7%Al coating to some extent , but they are not so deep as to be visualized from the surface.

Fig.1 indicates the relationship between the aluminum contents and depth of the dents on Zn-Al coating layers. It is obvious that the deepest dents are formed on the Zn-5%Al coatings. These deep grainboundary dents could be reduced to some extent by the additional rapid cooling with minimizing process or by skin-pass rolling. Even with these treatments, the grainboundary dents on the Zn-5%Al coatings reflected on the surface aspect of paint coated sheet. It could not meet the customers' severe demand for surface quality of paint coated sheets.

3.2.CORROSION RESISTANCE

Outdoor Exposure Test

Three types of coatings having coating weights of 45 g/m^2 and 120 g/m^2 have been exposed in the heavy industrial site described before.

Photo. 3 shows the appearance of representative specimens exposed for three years. The color of surface appears to be very dark due to patina. At X-scribed grooves, a small amount of reddish corrosion products are observed on every specimen. From visual observation, there was no apparent difference in corrosion among these three types of coatings.

Photo.4 represents the corrosion of coating layers observed from the cross-sectional view. The pictures show the most severely corroded sections. On the pictures of flat section, each coating layer is corroded uniformly from the surface side, and there is no evidence of preferential corrosion on a certain phase as is the case of 55%Al-Zn alloy coatings*.

All steel substrates are well protected with the sacrificial corrosion of the coating layers at the sheared edge as well as 2-t bended portion.

On the outdoor exposure test, no apparent difference in corrosion resistance among these three alloy coatings have been revealed so far.

Accelerated Corrosion Test

Photo. 5 and Photo.6 show the surface appearance of the specimens subjected to the salt spray test and the humidity cabinet test respectively. Their corrosion were almost the same regardless of the aluminum contents of coatings.

Fig. 2 indicates the relationship between the coating weight and the time to red-rusting in the salt spray test on three types of Zn-Al alloy coatings. Again in this data, corrosion resistance of three coatings are the same even on a higher coating weight, and the time to red-rusting is simply a function of the coating weight.

* D. J. Blickwede: TETSU-TO-HAGANE (JISI), Vol.66 (1980) p.821

3.3.FORMABILITY

The formability of Zn-4%Al, Zn-5%Al and Zn-7%Al alloy coatings are all better than conventional galvanized steel, and there is no obvious difference among the Zn-Al alloy coatings as indicated in Photo.7.

4.CONCLUSION

1)The Zn-5%Al eutectic alloy produces a significant degree of grainboudary dents on the coating surface, which is responsible for the poor surface quality of as-coated and paint-coated sheet.

2)The corrosion resistance of Zn-4%Al, Zn-5%Al and Zn-7%Al coatings reveal no apparent difference in three-year outdoor exposure test as well as accelerated corrosion test.

3)The formability of the coating layers is not influenced by their aluminum contents.

From these results, it is concluded that aluminum content ranging from 4 to 7% in Zn-Al alloy coatings had no substantial influence for the properties of coating layer except surface appearnce. Therefore, the aluminum contents of Galfan coating should be decided from a stand point of surface quality which has various criteria depending on the customers.

Table 1. Chemical composition of coating bath

(%)

	Al	Fe	Pb	La+Ce	Zn	Bath temp.
Zn-4%Al	4.04	0.021	0.003	0.013	bal.	440 °C
Zn-5%Al	5.10	0.019	0.003	0.012	bal.	440
Zn-7%Al	7.38	0.025	0.003	0.014	bal.	450

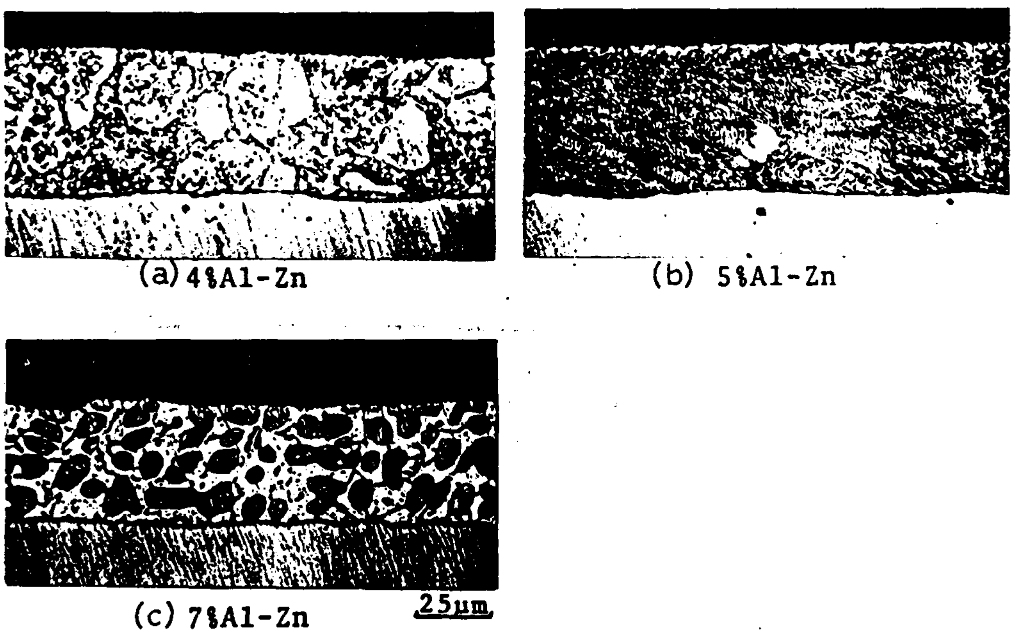
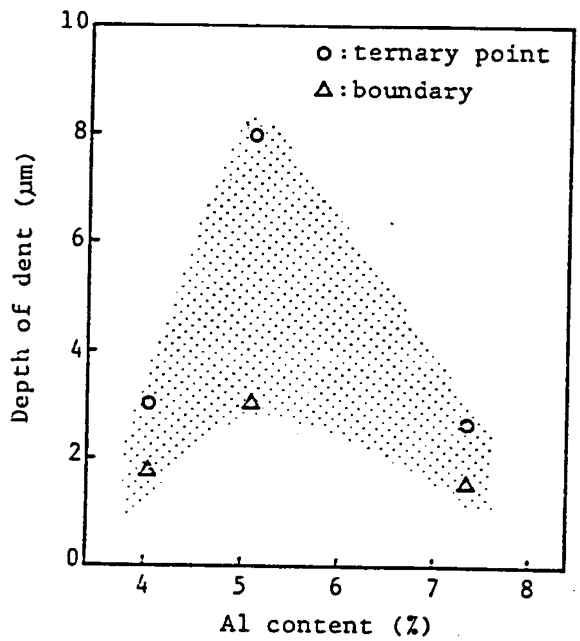


Photo. 1. Microstructure of the coating layer

x400

Photo. 2. Typical grainboundary dents on Zn-5%Al coatings



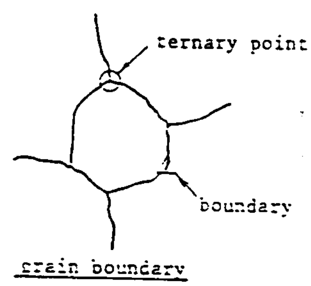
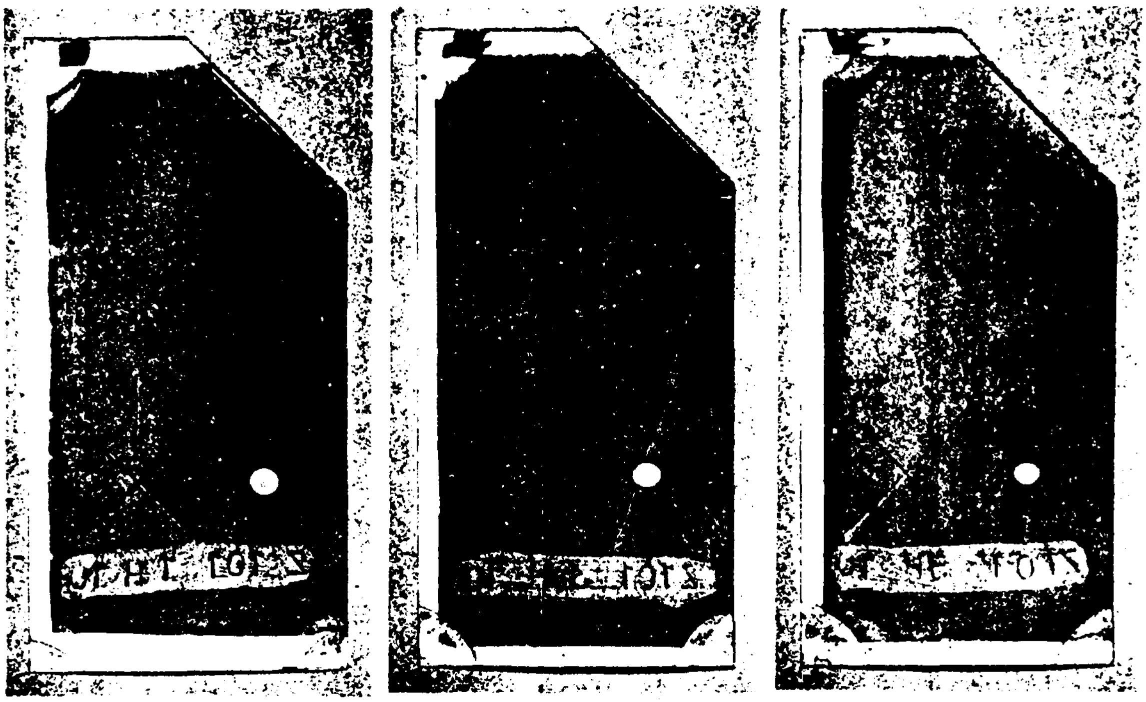


Fig. 1. Relationship between the depth of grainboundary dents and the coating compostion
(Coating weight: 120 g/m²)



x0.45

(a) Zn-4%Al (b) Zn-5%Al (c) Zn-7%Al

Photo. 3. Appearance of specimens exposed at heavy industrial area for three years
coating weight: 90 g/m^2
chemical treatment: non

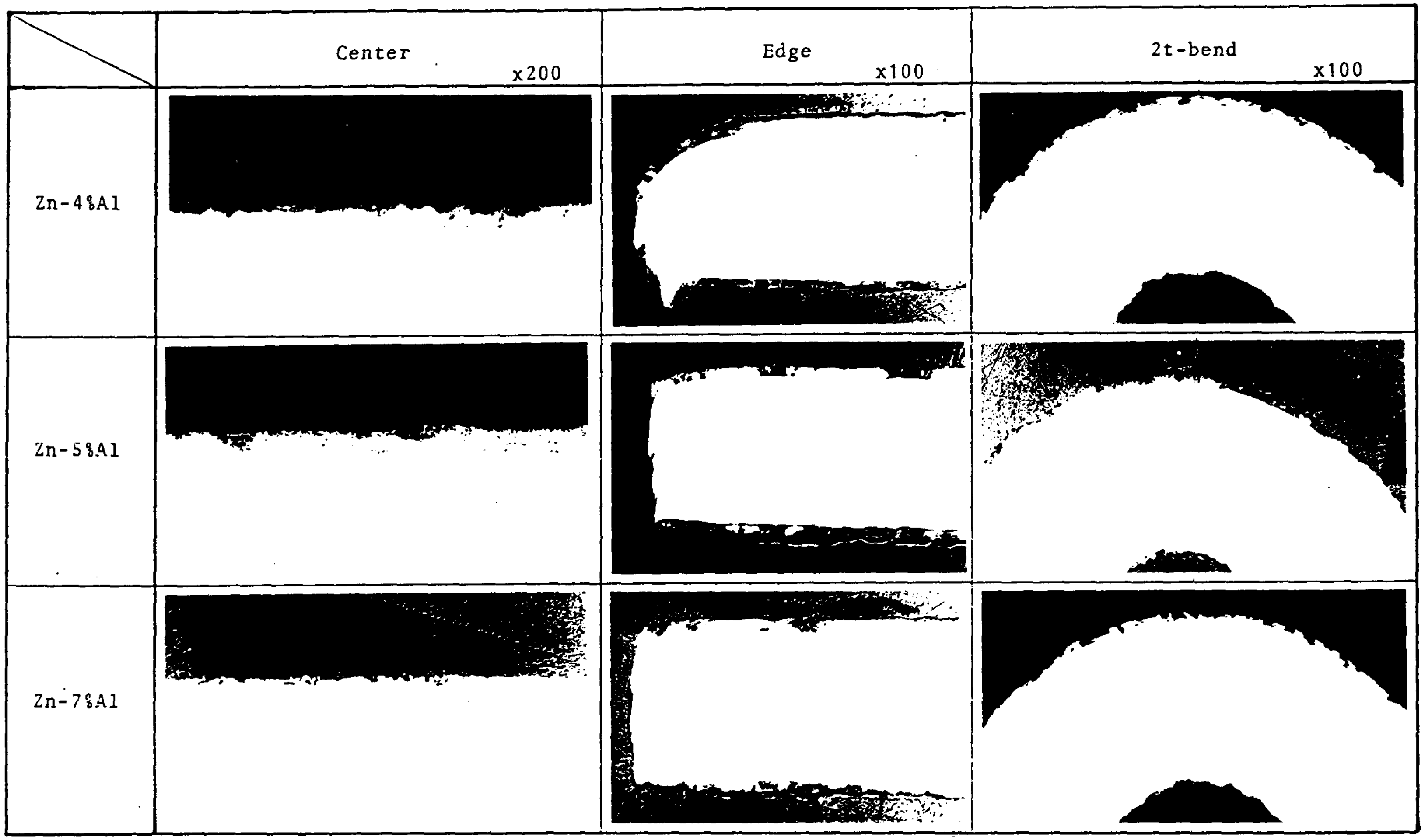
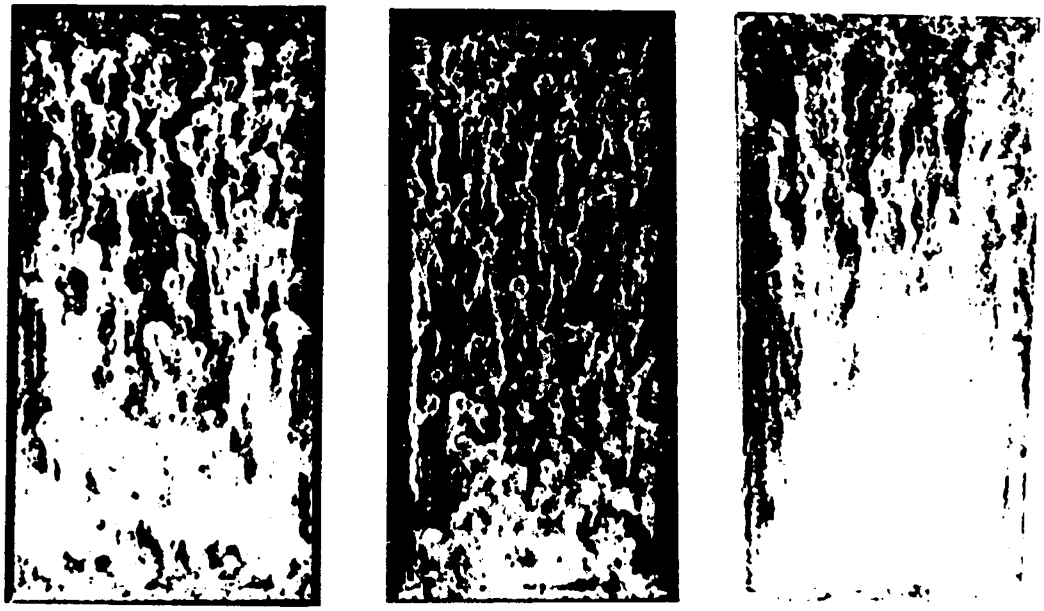


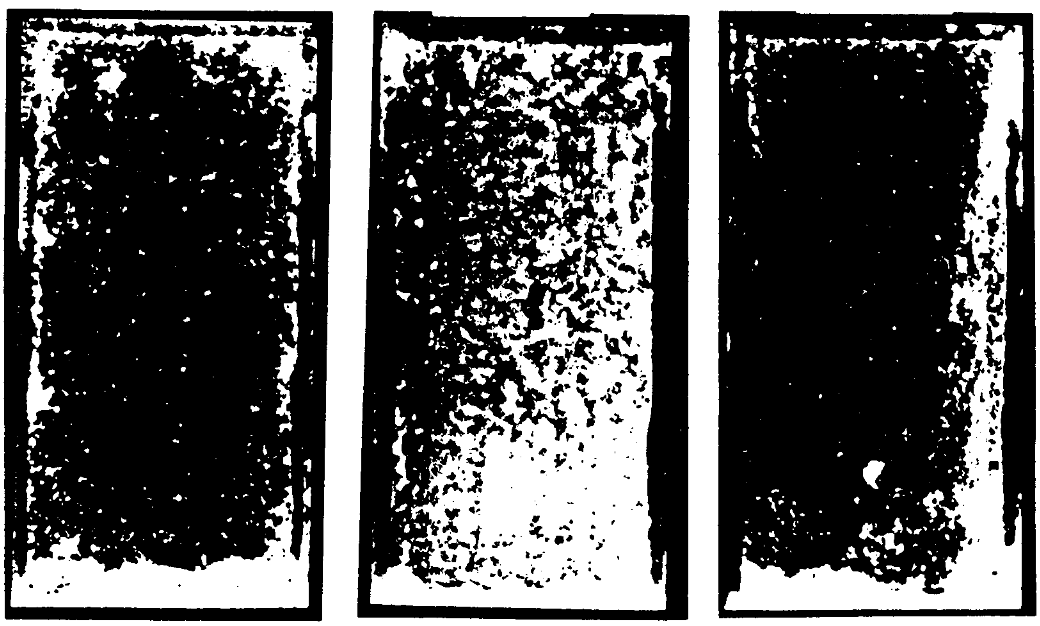
Photo. 4. Cross-sectional microstructure of outdoor-exposed specimens



4%Al-Zn 5%Al-Zn 7%Al-Zn

x0.6

Photo. 5. Appearance of specimens subjected to salt spray test for 1,000 hours



4%Al-Zn 5%Al-Zn 7%Al-Zn

x0.6

Photo. 6. Appearance of specimens subjected to humidity cabinet test for 2,500 hours

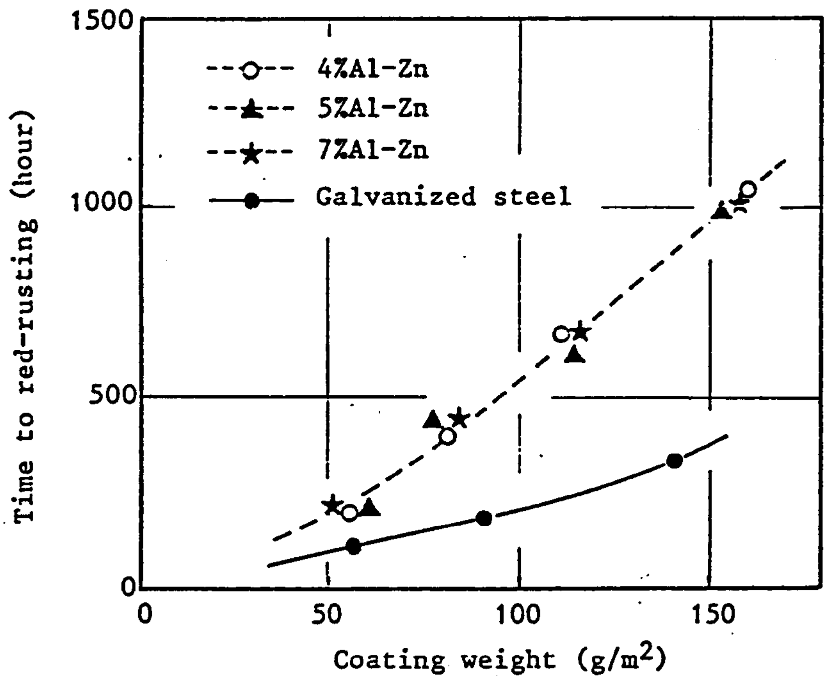
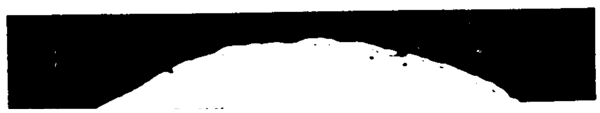
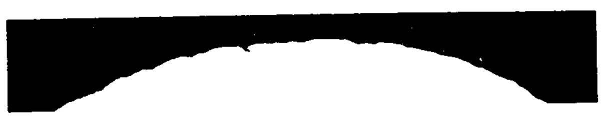


Fig. 2. Time to red-rusting in salt spray test

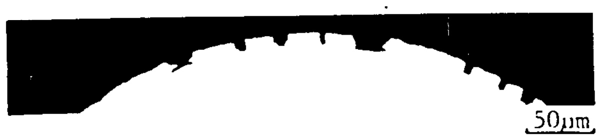
a) 4%Al-Zn



b) 5%Al-Zn



c) 7%Al-Zn



d) Galvanized

Photo. 7. Cross-section of 2t-bend specimens

ProCoat

PROTECCION Y RECUBRIMIENTOS

Camino de la Riera, s/n - Cova Solera - RUBI (Barcelona)

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Grupo BRUGAROLAS

FILM-FORMING PASSIVATION ON GALFAN MATERIALS.-

- An approach to state the behaviour of film-forming products on Galfan surfaces was made.
- We define as film-forming passivation, those products which perform a phospho-chromating action to zinc surfaces and deposit an organic polymer at the same time, through a one-step process.
- The corrosion protection effect and the development of products which could improve adhesion of paints onto Galfan surfaces has been the aim of this work.
- The following pictures show the corrosion tests results and schemas of the process.
- Common application methods are : by dip, flow coating and roll coaters.

[1] - Film-forming products were developed to provide high corrosion resistance to zinc materials. Test results are shown in this slide.

[2] - The development of a grey patina was observed when carrying on those tests and this being a well known fact. Different type of products were tested to prevent from darkening. No one, containing chromium, was able to delete this effect, only products free from chromium were successful.

[3] - The ability of these products to improve paint, whilst increasing corrosion resistance, lead to the following process and results.

[4] The described process is intended for general components industry, and tests were performed with different types of paints.

- A high thickness coating, developed from former passivating product, was tested also.

[5] This coating has pigments and thickeners in it, and can perform as a real paint. Requiring no previous pretreatment, except for cleaning.

[6] Its uses can be either as a primer or as a single coat process.

FILM-FORMING PASSIVATION.-

(containing Cr+6)

	CORROSION TESTS				
	SALT SPRAY			OUTDOORS EXPOSURE 18 months	
	WHITE RUST			WHITE RUST	COLOUR
	FLAT PANEL	DEEP DRAW 5mm	DEEP DRAW 7mm		
GALFAN (Matt)	600 H.	250H.	-	O.K.	DARKENING
GALFAN (Bright)	400 H.	-	200H.	O.K.	DARKENING

BRIGHT GALFAN

FILM-FORMING PASSIVATION (Cr+6 Free).-

	DARKENING TEST HUMIDITY CABINET				SALT SPRAY	
	40ºC | 98% RH		49ºC | 98% RH			
EXPOSURE TIME	500H	3000H	250H	500H	48H	72H
DARKENING	10	9	10	-	-	-
WHITE RUST	9	8	10	9	9	7

10 = NO EVIDENCE OF CHANGE / 0 = TOTAL FAILURE

FILM-FORMING PRETREATMENT

FOR PAINT PROCESSES.-

FILM-FORMING	CONVENTIONAL
DEGREASING	DEGREASING
RINSING	RINSING
FILM-FORMING	PHOSPHATING
DRYING	RINSING
SEALER	PASSIVATING RINSE
TOP COAT	DRYING
	CATHODIC ELECT.
	RINSING
	STOVING
	SEALER
	TOP COAT

FILM-FORMING PRETREATMENT FOR PAINT PROCESSES

METAL + F.F. + PRIMER + TOP COAT

	SALT SPRAY 1000H.	COMBINED S.S. and CLIMATIC TEST 10 cycles
WHITE RUST at scratch	< 2 mm.	< 1 mm.
CREEPAGE at scratch	< 1 mm.	< 1 mm.

METALS : GALFAN Matt and Bright (Skin passed)
PAINTS : ALKYD and ACRYLIC systems.

PHOSPHATING PAINT.-

As a PRIMER	As a SINGLE COAT
DEGREASING	DEGREASING
RINSING	RINSING
DRYING	DRYING
F.F. PRIMER	F.F. PAINT
CURING	CURING
TOP COAT	
CURING	

PHOSPHATING PAINT.-

	SALT SPRAY						SO2 (KESTERNICH)	
	CROSS HATCH			EDGE (Creepage,mm)			5 cycles	8 cycles
	300h	500h	700h	300H	500h	700h		
PRIMER (Polyester Top Coat).	10	10	10	1	3	5–6	–	–
SINGLE COAT								
10 μ	10	7	–	1	2	–	–	–
20 μ	10	10	10	1	3	7–8	10	8x

10 = BEST RESULTS / 0 = TOTAL FAILURE / 8x = LOSS OF GLOSS

GALFAN

- LE NOUVEAU REVÊTEMENT A BASE DE ZINC POUR PROTÉGER LA TÔLE ET LE FIL.
- LE NOUVEAU REVÊTEMENT AUX PROPRIÉTÉS EXCEPTIONNELLES DE TENUE A LA CORROSION, DE PROTECTION CATHODIQUE, DE FORMABILITÉ, D'EMBOUTISSABILITÉ, D'APTITUDE AU SOUDAGE ET A LA PEINTURE.
- LE NOUVEAU REVÊTEMENT PERFORMANT QUI COMPLÈTE LA GAMME DES REVÊTEMENTS ZINC DISPONIBLES SUR LE MARCHÉ.

GALFAN

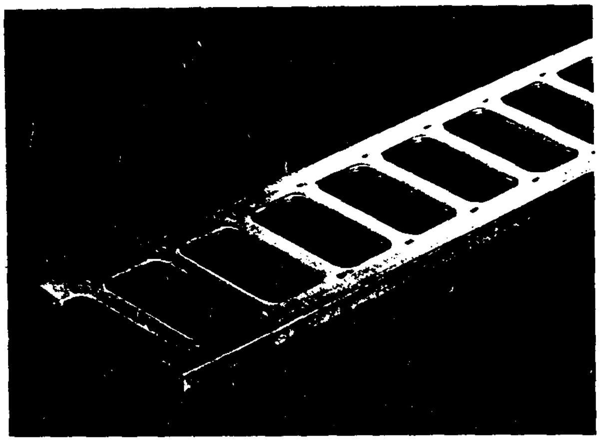
- **THE NEW ZINC BASED COATING TO PROTECT STEEL SHEET AND WIRE.**
- **THE NEW COATING WITH EXCEPTIONAL CORROSION PERFORMANCE, SACRIFICIAL PROTECTION, FORMABILITY, WELDABILITY AND PAINTABILITY.**
- **THE NEW HIGH-PERFORMANCE COATING WHICH COMPLEMENTS THE RANGE OF COMMERCIALLY AVAILABLE ZINC COATINGS.**

GALFAN

- *NUOVO RIVESTIMENTO A BASE DI ZINCO PER PROTEGGERE LA LAMIERA E IL FILO.*
- *NUOVO RIVESTIMENTO DALLE ECCEZIONALI PROPRIETA' DI RESISTENZA ALLA CORROSIONE, DI PROTEZIONE CATODICA, DI FORMABILITA', IMBUTITURA, SALDABILITA' E VERNICIABILITA'.*
- *NUOVO RIVESTIMENTO AD ELEVATE PRESTAZIONI CHE COMPLETA LA GAMMA DEI RIVESTIMENTI ZINCATI DISPONIBILI SUL MERCATO.*

GALFAN

- DER NEUE ZINKÜBERZUG SCHÜTZT BLECH UND DRAHT.
- DER NEUE ÜBERZUG MIT DEN AUSSERGEWÖHNLICHEN EIGENSCHAFTEN KORROSIONSBESTÄNDIG, KATHODISCHER SCHUTZ, UMFORMBAR, TIEFZIEHBAR, SCHWEISSBAR BESCHICHTBAR.
- DER NEUE HOCHLEISTUNGSFÄHIGE ÜBERZUG, ERGÄNZT DIE BISHER AUF DEM MARKT BEFINDLICHEN ZINKÜBERZÜGE.



HOESCH : Pare-neige / Snow guard
Paraneve /

GALFAN

LE NOUVEAU REVÊTEMENT A BASE DE ZINC POUR PROTÉGER LA TÔLE ET LE FIL.

Au fil des années, des recherches ont visé à accroître le champ d'application des tôles pré-revêtues par le zinc en améliorant les propriétés des revêtements. Elles ont conduit à la mise au point de nouveaux produits : Galvalume®, Superzinc®, Aluzinc®... chacun avec ses qualités propres, et au **GALFAN** qui se distingue sur tous les plans : tenue à la corrosion, protection cathodique, formabilité, emboutissabilité, aptitude au soudage et au prélaquage.

Ces propriétés font de GALFAN LE PRODUIT NOUVEAU D'AUJOURD'HUI ET DE DEMAIN.

GALFAN est un alliage de zinc de haute pureté à 5 % d'aluminium additionné de terres rares (Lanthane, Cerium), destiné à la galvanisation au trempé sur des lignes continues. Le bon comportement à la corrosion des alliages de zinc à 5 % d'Aluminium est reconnu depuis plusieurs années. Les recherches entreprises sous l'égide de l'ILZRO (Organisation Internationale de Recherches pour le zinc et le plomb) par le Centre de Recherches Métallurgiques à Liège (Belgique), ont permis de mettre en évidence le rôle positif d'un ajout de terres rares à cet alliage.

GALFAN

SES PROPRIÉTÉS EXCEPTIONNELLES FONT LA DIFFÉRENCE

- Sa résistance à la corrosion.
- Sa protection cathodique.
- Sa formabilité.
- Son emboutissabilité.
- Son aptitude au soudage.
- Son aptitude au prélaquage.

font de **GALFAN** le produit que l'on attendait.

Son application dans les domaines traditionnels et les plus divers, illustrée dans cette brochure, le prouvent.

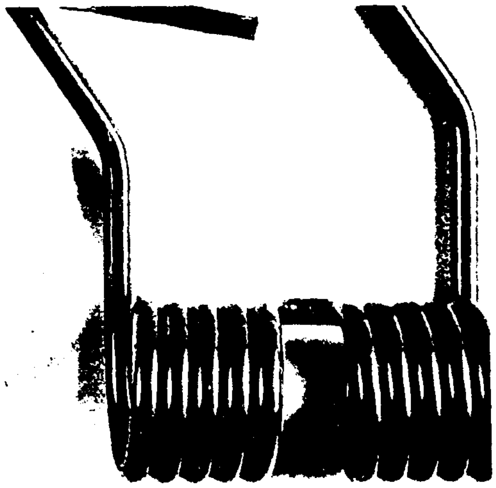
GALFAN

THE NEW ZINC BASED COATING TO PROTECT STEEL SHEET AND WIRE.

Years of research have been devoted to broadening the field of application of zinc coated steel sheet, by improving the properties of the coatings. They have led to the introduction of new products : Galvalume, Superzinc, Aluzinc,... each with its own special qualities, and now to GALFAN which is distinguished in all ways : corrosion behaviour, sacrificial protection, formability, drawability, and suitability for welding and prepainting.

These properties make GALFAN the NEW PRODUCT FOR TODAY AND TOMORROW.

GALFAN coating is produced on continuous hot dip galvanizing lines from an alloy of high purity zinc and 5 % aluminium, with the addition of rare earths (lanthanum, cerium). The excellent corrosion resistance of zinc-5 % aluminium alloys has been recognised for several years. Researches carried out under the sponsorship of the International Lead Zinc Research Organization (ILZRO) at the Centre de Recherches Metallurgiques at Liège, Belgium, have established and quantified the role of the rare earth additions.



FICAL : Ressorts / [illegible]

GALFAN

AN EXCEPTIONAL COMBINATION OF PROPERTIES

- **Corrosion resistance.**
- **Cathodic protection.**
- **Formability.**
- **Drawability.**
- **Weldability.**
- **Paintability.**

make GALFAN the product you've been waiting for. The new and traditional applications illustrated in this brochure give some idea of its potential.

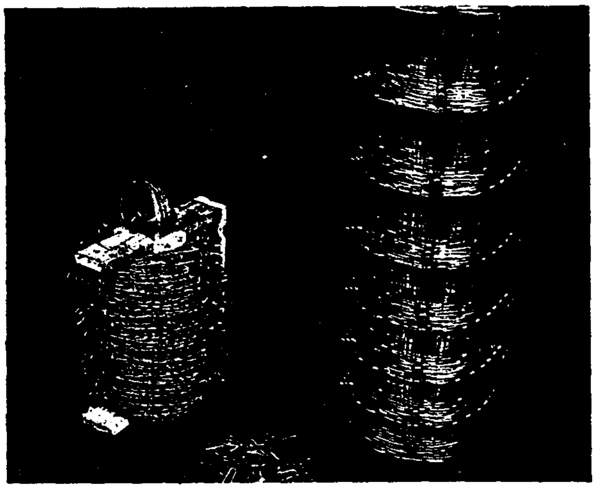
GALFAN®

GALFAN
NUOVO RIVESTIMENTO A BASE DI ZINCO PER I PRODOTTI [illegible] LAMIERE E FILI

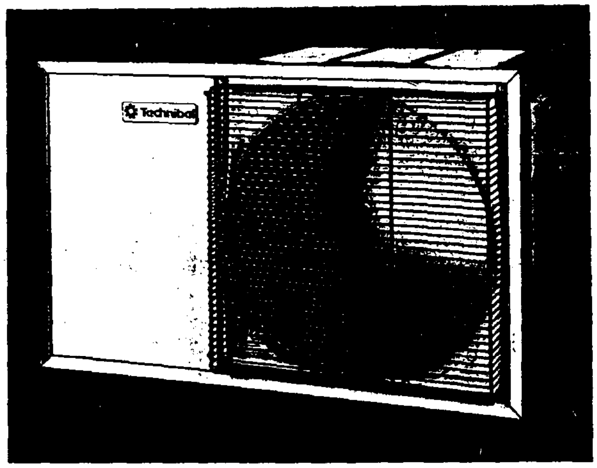
*Nel corso degli anni sono state condotte delle ricerche per ampliare il campo di applicazione delle lamiere privestite con zinco e migliorandole proprièta dei rivestimenti. Nuovi prodotti sono nati : Galvalume, Superzinc, Aluzinc... ciascuno con proprie caratteristiche, ed il **GALFAN** che si distingue dagli altri per : resistenza alla corrosione, protezione catodica, formabilità, imbutitura, saldabilità e verniciabilità.*

Queste proprietà ne fanno il PRODOTTO NUOVO DEL PRESENTE E DEL FUTURO.

***GALFAN** è una lega di zinco di elevata purezza al 5 % di alluminio con aggiunta di terre rare (Letalio e Cerio) destinata alla zincatura a caldo in continuo. L'elevata resistenza alla corrosione delle leghe di zinco al 5 % di alluminio è nota da diversi anni. Le ricerche intraprese sotto il patrocinio dell'ILZRO (Organizzazione Internazionale di Ricerche per lo Zinco e il Piombo) e dal Centre de Recherches Métallurgiques di Liegi (Belgio), hanno permesso di evidenziare il ruolo positivo dell'aggiunta di terre rare a detta lega.*



FICAL : Fil / Wire / Filo /



ZIEGLER : Convecteur / Heat-exchanger /

GALFAN

Langjährige Untersuchungen zur Anwendungserweiterung von verzinktem Feinblech hatten zur Aufgabe, die Eigenschaften des Überzüges zu verbessern. Diese Forschungen führten zur Entwicklung von neuen Produkten wie Galvalume, Superzinc, Aluzinc..., jedes einzelne Produkt mit speziellen Eigenschaften, und vor allen Dingen zur Entwicklung von **GALFAN,** welches sich in allen Punkten deutlich unterscheidet : Korrosionsbeständigkeit, kathodischer Schutz, Umformbarkeit, Tiefziehbarkeit, Schweissbarkeit und Grundierbarkeit für Beschichtungen.

Diese Eigenschaften machen GALFAN zum NEUEN PRODUKT VON HEUTE UND MORGEN.

GALFAN ist eine hochreine Zinklegierung mit 5 % Aluminium und Zusatz von seltenen Erden (Mischmetall Lanthan, Cer). Es ist bestimmt für die kontinuierliche Feuerverzinkung von Feinblech. Die ausgezeichnete Korrosionsbeständigkeit von Zinklegierungen mit 5 % Aluminium ist seit Jahren bekannt. Die unter der Aufsicht der ILZRO (International Lead Zinc Organization) durch das Forschungszentrum für Metallurgie in Lüttich (Belgien) durchgeführten Untersuchungen bewiesen die positive Wirkung des Zusatzes von seltenen Erden zu der 5 % Aluminium-Zink-Legierung.

GALFAN
LE SUE ECCEZIONALI PROPRIETA' LO RENDONO DIVERSO

- *Resistenza alla corrosione.*
- *Protezione catodica.*
- *Formabilità.*
- *Imbutitura.*
- *Saldabilità.*
- *Verniciabilità.*

*fanno di **GALFAN** il prodotto ideale.*

Ne sono la riprova le sue applicazioni nei campi tradizionali e più diversi, illustrati in questo opuscolo.

GALFAN

- seine Korrosionsbeständigkeit.
- sein kathodischer Schutz.
- seine Umformbarkeit.
- seine Tiefziehfähigkeit
- seine Schweissbarkeit.
- seine Grundierbarkeit für Beschichtungen.

machen aus dem **GALFAN** den seit langem erwarteten Werkstoff. Seine Anwendungen auf den verschiedensten in diesem Heft angeführten Gebieten sind der Beweis dafür..

GALFAN
UNE EXCELLENTE TENUE A LA CORROSION

La supériorité du **GALFAN** est prouvée à la fois par des essais atmosphériques et par des essais de corrosion accélérée. Ces expériences ont commencé en 1979 au Centre de Recherches Métallurgiques à Liège et, depuis, les licenciés **GALFAN** poursuivent des études complémentaires.

Les essais accélérés en Laboratoire (brouillard salin, atmosphère SO_2) ont permis de comparer les performances du **GALFAN** avec les revêtements galvanisés traditionnels.

Les figures 1, 2 et 3 illustrent les résultats des tests en brouillard salin (5 %) et en atmosphère SO_2 (6 ppm). La figure 2 montre que le temps nécessaire à la formation de 5 % de rouille rouge sur une tôle **GALFAN** est 2, voire 3 fois plus long que sur le galvanisé traditionnel.

En atmosphère SO_2, le **GALFAN** a un comportement encore plus remarquable : sur la figure 3, on peut voir que la perte d'épaisseur du revêtement **GALFAN** est inférieure à celle du galvanisé et qu'elle est équivalente au Galvalume.

Les essais de corrosion longue durée en atmosphère naturelle, qui sont toujours en cours, prouvent que la durée de vie du rêvetement **GALFAN** est d'environ 50 % supérieure à celle du galvanisé traditionnel.

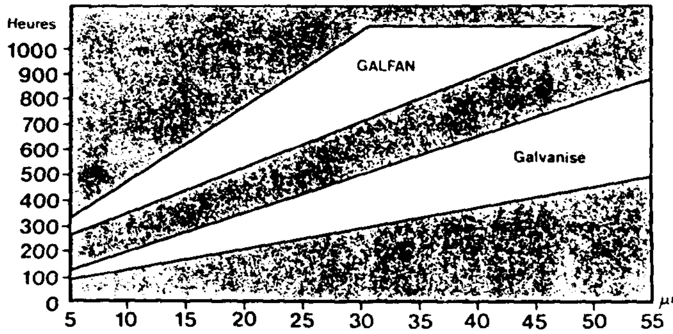


Fig. 2 - C.R.M. : Résultats d'essais de brouillard salin 5 %
Results of 5 % salt spray tests / *Prove in atmosfera salina*

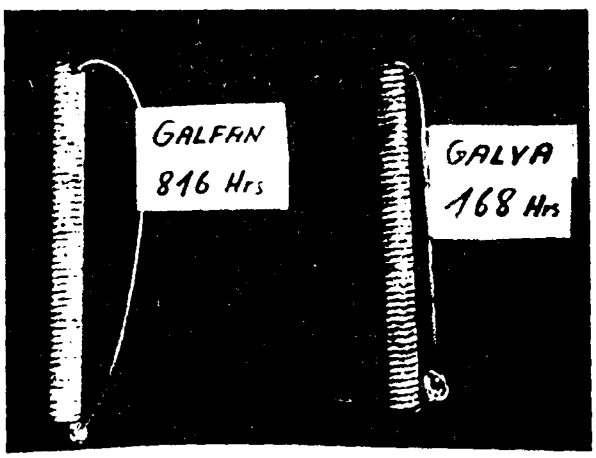


Fig. 1 - C.R.M. : Après essais de corrosion brouillard salin
After salt spray test
Dopo le prove di corrosione in atmosfera salina

GALFAN
EXCELLENT CORROSION PERFORMANCE

The superiority of GALFAN coated sheet has been established by both atmospheric tests and accelerated corrosion testing. Tests were started in 1979 at the Centre de Recherches Metallurgiques in Liège, Belgium, and additional programmes have since been initiated by GALFAN licensees in Europe : these are continuing. Accelerated laboratory tests carried out in salt fog and SO_2 atmosphere have enabled performance of GALFAN to be compared with that of conventional zinc coatings.

Figures 1, 2 and 3 show the results of salt fog (5 %) and SO_2 (6 ppm) tests. Figure 2 shows that the time to form 5 % red rust on GALFAN coated sheet is two or three times longer than the time required using galvanized sheet.

The performance of GALFAN in an SO_2 atmosphere is even more impressive : Figure 3 shows that the loss of coating thickness on GALFAN is less than that for galvanized and equivalent to that of Galvalume. Long term outdoor corrosion tests which are continuing, indicate that coating life for GALFAN is typically over 50 % more than for conventional galvanizing.

GALFAN®
OTTIMA RESISTENZA ALLA CORROSIONE

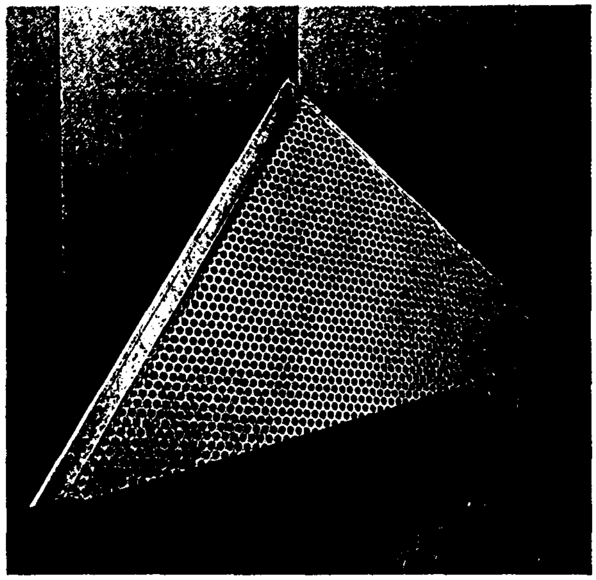
*La superiorità del **GALFAN** è confermata sia dalle prove atmosferiche che dalle prove di corrosione accellerata. Queste sperimentazioni sono state iniziate nel 1979, presso il Centre de Recherches Métallurgiques di Liegi e sviluppate successivamente dai Licenziatari **GALFAN**.*

*Le prove accellerate eseguite in laboratorio (nebbia salina, atmosfera SO_2) hanno permesso di confrontare le prestazioni del **GALFAN** con quelle dei rivestimenti zincati tradizionali.*

*Le fig. 1, 2 e 3 riportano i risultati delle prove in nebbia salina (5 %) e in atmosfera (6 ppm). La figura 2 mostra che il tempo necessario alla formazione del 5 % de ruggine rossa su una lamiera **GALFAN** è due-tre volte superiore a quello sullo zincato tradizionale.*

*In atmosfera SO_2, il **GALFAN** ha un comportamento ancora più sorprendente : nella fig. 3 si può notare che la perdita di spessore del rivestimento **GALFAN** è inferiore a quella dello zincato e uguale a quella del Galvalume.*

Le prove di corrosione a lunga durata in atmosfera naturale, tuttora in corso, confermano che le perdite di spessore del rivestimento zincato sono del 50 % inferiore a quelle dello zincato tradizionale.



ZIEGLER : Convecteur / Heat-exchanger
Convettore /

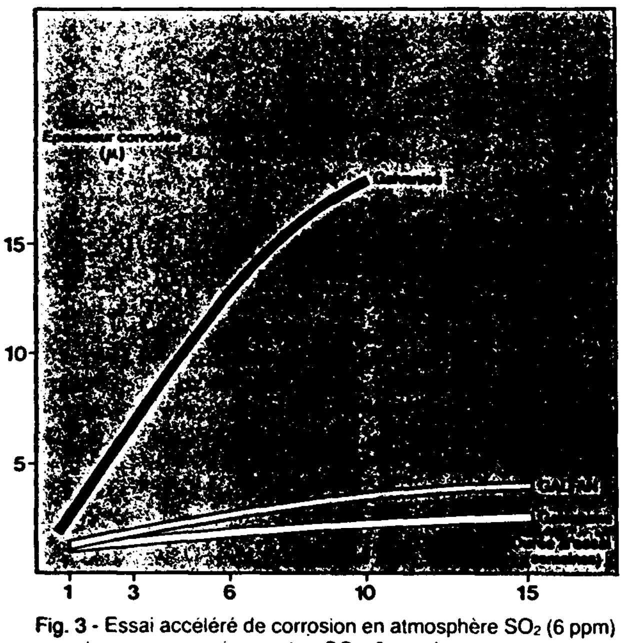


Fig. 3 - Essai accéléré de corrosion en atmosphère SO_2 (6 ppm)
ccelerated corrosion tests - SO_2 (6 ppm)
Prove accelerate di corrosione in atmosfera SO_2 (6 ppm)

GALFAN®

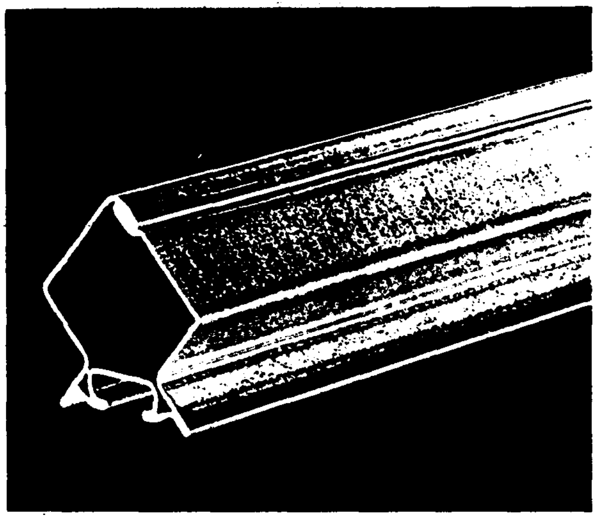
Die Überlegenheit von **GALFAN** wurde sowohl bei atmosphärischen Versuchen als auch bei beschleunigten Korrosionsversuchen unter Beweis gestellt. Die genannten Versuche begannen 1979 im Forschungszentrum für Metallurgie in Lüttich und wurden durch **GALFAN**Lizenzhersteller in weiteren Versuchen ergänzt.

Im Rahmen von Labor-Schnellversuchen (Salzsprühnebel, SO_2-Atmosphäre) wurden die Leistungen von **GALFAN** mit jenen herkömmlich verzinkter Werkstoffe verglichen.

Bild 1, 2 und 3 zeigen die Testergebnisse im Salzsprühnebel (5 %) und in SO_2-Atmosphäre (6 ppm). Abbildung 2 beweist, dass die für die Bildung von 5 % Rotrost erforderliche Zeitdauer auf einem **GALFAN**-Blech zwei-bis dreimal länger ist als bei normal verzinkten Blechen.

In SO_2-Atmosphäre weist **GALFAN** ein noch besseres Verhalten auf. Bild 3 zeigt dass der Verlust an Dicke des aufgetragenen **GALFAN**-Überzuges unter jenem des verzinkten Materials liegt, gleichrangig mit jenem des Galvalume.

Langzeitliche Korrosionsversuche in freier Atmosphäre, welche gegenwärtig noch andauern, zeigen, dass die Lebensdauer der **GALFAN**-beschichteten Werkstoffe etwa 50 % mehr ist als bei herkömmlich verzinkten Blechen.



HOESCH : Profilé trapézoidal / Trapezoidal profile
Profilato trapezoidale /

GALFAN

UNE FORMABILITÉ ET UNE EMBOUTISSABILITÉ EXCEPTIONNELLES

Les essais comparatifs, réalisés en Laboratoire, montrent que le **GALFAN** est plus ductile que les autres revêtements.

Pour que la mise en forme de l'acier revêtu soit parfaite il faut que le revêtement adhère bien et demeure intact pendant les sollicitations. **GALFAN** satisfait cet objectif et ceci est dû, entre autres, à :

- l'absence quasi totale d'une couche de composés intermétalliques fragiles entre l'acier et le zinc
- la ductilité inhérente à l'alliage à 5 % d'aluminium
- la structure eutectique à grains fins de l'alliage, qui minimise la propagation des fissures dans le revêtement.

Les essais de laboratoire sont confirmés par les applications industrielles présentées ; elles montrent que le **GALFAN** convient particulièrement bien dans les applications d'emboutissage profond, de profilages et de pliages multiples et sévères.

GALFAN

UNE BONNE APTITUDE AU SOUDAGE

Son aptitude au soudage s'avère satisfaisante si nous la comparons au galvanisé traditionnel. Dans tous les cas, elle est supérieure aux revêtements fortement alliés à l'aluminium du type Galvalume, Zincalume, Aluzinc...

Dans des conditions adaptées, l'utilisation d'une électrode dont la configuration est représentée figure 4 permet d'obtenir de bons résultats avec une durée de vie satisfaisante.

GALFAN

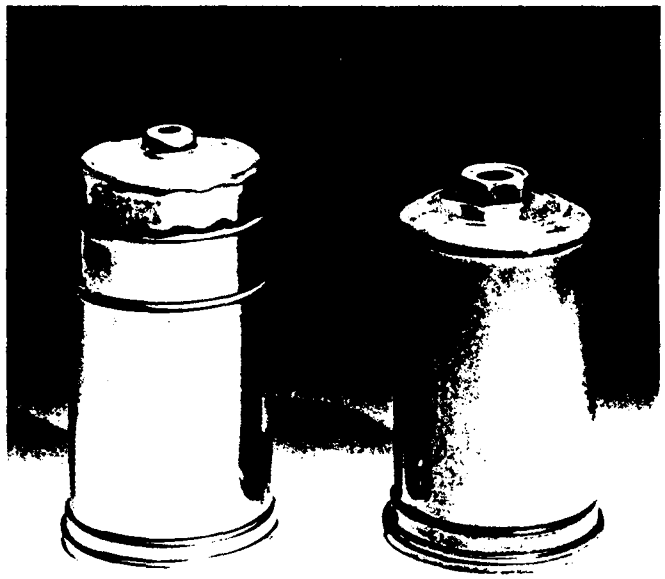
[illegible]

Comparative tests show that GALFAN is more ductile than other coatings.

For easy forming of zinc coated steel, the coating should adhere well and remain intact during working. GALFAN meets these requirements due, amongst other things, to the following :

- **almost complete absence of a brittle intermetallic layer between the steel and the zinc.**
- **the inherent ductility of the zinc 5 % aluminium alloy**
- **the fine grain eutectic structure which minimises the propagation of cracks in the coating.**

The laboratory tests are confirmed by the applications illustrated here, showing that GALFAN is particularly suitable for applications involving deep drawing, profiling and multiple severe bending operations.



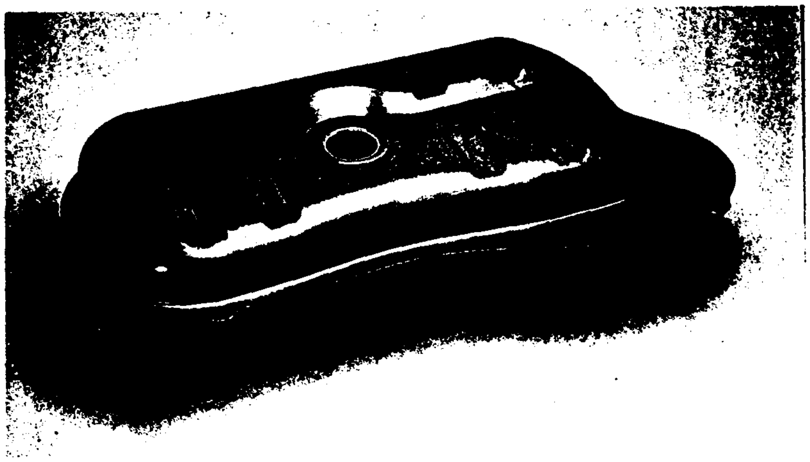
HOESCH : Filtre à huile de voiture / Motor car oil filter
[illegible] /

GALFAN

GOOD WELDABILITY

The weldability of GALFAN is satisfactory in comparison to traditional galvanizing, and is always better than the higher aluminium coating such as Galvalume, Zincalume, Aluzinc...

With the welding conditions properly adjusted, and using an electrode configuration such as that shown in Fig. 4, good welds and a satisfactory electrode life can be obtained.



ZIEGLER : Réservoir à essence /

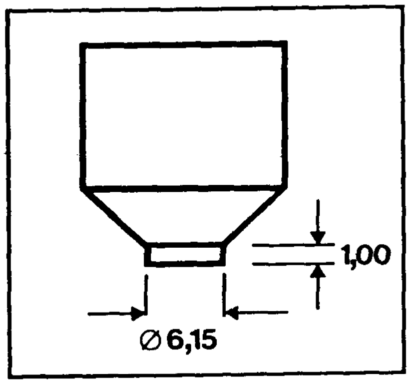


Fig. 4 - C.R.M. : Profil d'électrode pour souder le Galfan

GALFAN
FORMABILITÀ E IMBUTITURA ECCEZIONALI

*Le prove comparative eseguite in laboratorio, mostrano che il **GALFAN** è più duttile rispetto agli altri rivestimenti.*

*Affinchè la formatura dell'acciaio rivestito sia perfetta, occorre che il rivestimento aderisca bene e rimanga intatto durante le sollecitazioni. Il **GALFAN** risponde a questo obiettivo e ciò è dovuto, fra l'altro, a :*

- *assenza quasi totale di uno strato di composti intermetallici fragili tra l'acciaio e lo zinco ;*
- *la duttilità inerente alla lega al 5 % di alluminio ;*
- *la struttura eutettica a grana fine della lega che riduce al minimo la diffusione di fessure nel rivestimento.*

*Le prove in laboratorio sono confermate dalle applicazioni industriali le quali dimostrano che il **GALFAN** è particolarmente adatto nelle operazioni di imbutitura profonda, di profilatura e piegature multiple e severe.*

GALFAN

In der Prüfanstalt durchgeführte Vergleichsversuche ergaben eine bessere Duktilität von **GALFAN** gegenüber anderen Überzügen.

Um eine vollkommene Formgebung des **GALFAN**-verzinkten Stahls zu erreichen, ist es erforderlich, dass der Überzug gut haftet und während der Umformung nicht beschädigt wird. Mit **GALFAN** wird dies erreicht. Die Gründe dafür sind folgende :

- Praktisch keine aus spröden intermetallischen Phasen bestehende Schicht zwischen Stahlblech und Zinküberzug.
- Eigenduktilität der Legierung mit 5 % Aluminiumzusatz
- Feinkörnige eutektische Struktur der Legierung ; dadurch weitgehende Einschränkung von Rissausbreitung im Überzug.
- Die Versuche in der Prüfanstalt wurden durch die angeführten Anwendungsbeispiele bestätigt. Sie beweisen, dass **GALFAN** ganz besonders für die Anwendungen bei extremen Tiefungen, bei der Profilherstellung und bei besonders scharfkantigen Mehrfachbiegungen geeignet ist.

GALFAN
BUONA SALDABILITA'

La saldabilità si rileva soddisfacente se paragonata con quella dello zincato tradizionale. In ogni caso è superiore a quella dei rivestimenti maggiormente legati all'alluminio, tipo Galvalume, Zincalume, Aluzinc...

In condizioni adatte, l'utilizzazione di un elettrodo (vedere illustrazione n. 4) permette di ottenere ottimi risultati con una durata di vita soddisfacente.

GALFAN

Im Vergleich zu herkömmlich verzinkten Werkstoffen kann die Schweissbarkeit als zufriedenstellend betrachtet werden. Sie ist in allen Fällen besser als die der mit Aluminium legierten Werkstoffe wie Galvalume, Zincalume, Aluzinc...

Unter gegebenen Umständen werden bei Verwendung einer Elektrode, wie sie in Bild 4 dargestellt ist, sehr gute Ergebnisse mit zufriedenstellender Lebensdauer erzielt.

GALFAN®
UNE PROTECTION CATHODIQUE PROPRE AUX REVÊTEMENTS ZINC

La protection cathodique est une propriété caractéristique des revêtements Zinc. Elle permet la protection des tranches et des surfaces endommagées par des rayures, éraflures, ou autres détériorations.

GALFAN conserve cette propriété parce que sa teneur en aluminium est relativement faible (5 %) ce qui n'est pas le cas des revêtements à 55 % d'aluminium du type Galvalume, Zincalume...

La superiorité du **GALFAN** sur les revêtements riches en aluminium (55 %) est illustrée par l'essai de corrosion en atmosphère SO_2 réalisé sur une tôle ayant subi une déformation lors d'un essai d'emboutissage Erichsen.

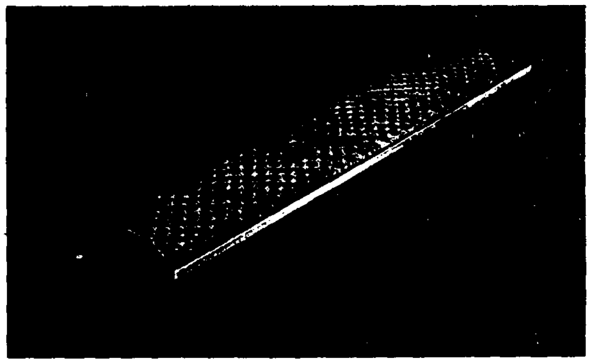
Après 10 semaines, l'aspect du **GALFAN** est resté intact, alors que celui du Galvalume est affecté par une coloration rouge démontrant que l'acier est attaqué.

HOESCH : Boîtier de ventilateur / Fan housing
[illegible] /

GALFAN®
UNE BONNE APTITUDE A LA PEINTURE

Les tôles **GALFAN** peuvent être peintes avec les prétraitements adaptés et les finitions habituelles.

Dans les applications du bâtiment et de l'électroménager, on peut utiliser différents types de primaires (Epoxy à l'eau, par exemple) sur lesquels toute gamme de peintures de finition est applicable (Polyester, PVC, acrylique et plastisol). Les primaires spéciaux développés dans l'industrie automobile peuvent être également appliqués avec succès.



F.F.M. : Marche d'escabeau / Part of a step-ladder
[illegible] /

GALFAN®
THE SACRIFICIAL PROTECTION OF A ZINC COATING

Sacrificial protection is an essential property of zinc coatings, ie. they can prevent steel from rusting even at small gaps in the coating giving protection to cut edges and to surfaces damaged by scratches, abrasion or other means.

GALFAN retains this property because its aluminium content is relatively low (5 %), which is not the case with the 55 % aluminium coatings such as Galvalume, Zincalume...

The superiority of **GALFAN** over the high aluminium (55 %) coatings is illustrated by a corrosion test in SO_2 atmosphere, carried out on sheet which had been subjected to an Erichsen test.

After 10 weeks the appearance of **GALFAN** is still satisfactory, while the Galvalume shows red coloration indicating that the steel has been attacked.

GALFAN®
GOOD PAINTABILITY

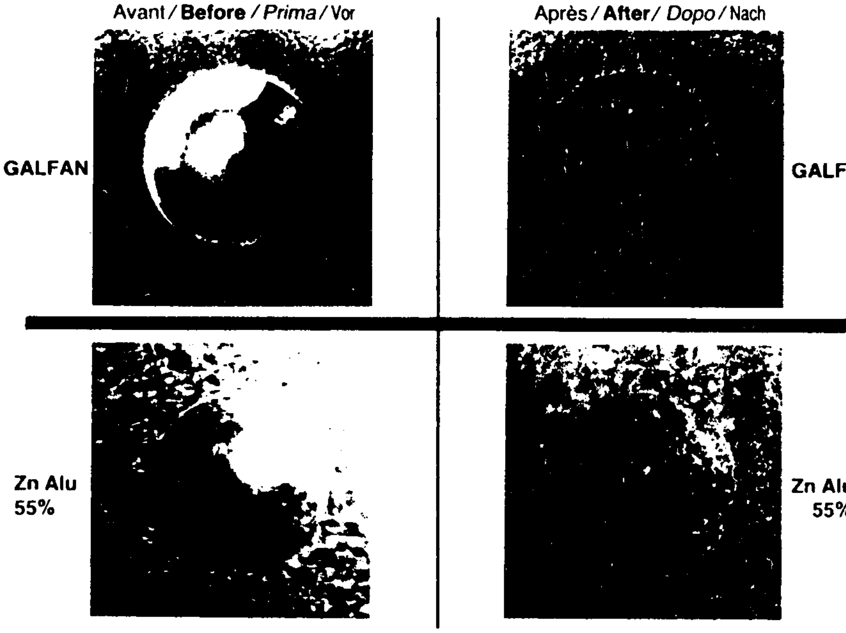
After specially adapted pretreatments, GALFAN sheet can be given any conventional paint coating.

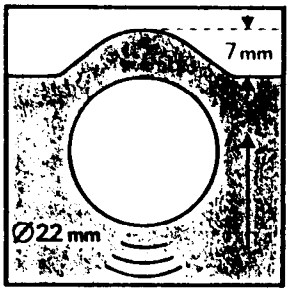
In buildings and domestic appliances different types of primer can be used (water-based epoxy, for example). The whole range of top coats can then be applied (polyester, PVC, acrylic, and plastisol) subject only to specific compatibility requirements which will normally be advised by the paint manufacturer. The special primers developed in the automotive industry can also be applied successfully.

Avant / **Before** / *Prima* / Vor — Après / **After** / *Dopo* / Nach

GALFAN — GALFAN

Zn Alu 55% — Zn Alu 55%





Essai d'emboutissage Erichsen
Erichsen deep drawing tests
Prove d'imbutitura Erichsen

Aspect des échantillons déformés avant et après essais de corrosion accélérés en atmosphère SO_2
Appearance of deformed specimens before and after accelerated corrosion tests in SO2 atmosphere
Aspetto dei campioni deformati prima e dopo le prove accelerate di corrosione in atmosfera SO

GALFAN

PROTEZIONE CATODICA PROPRIA DEI RIVESTIMENTI ZINCATI

La protezione catodica è una proprietà caratteristica dei rivestimenti in zinco. Permette la protezione delle parti e superfici dannegiate de rigature, graffi ed altro.

***GALFAN** conserva questa proprietà essendo il suo tenore in alluminio relativamente debole (5 %) contrariamente al rivestimenti al 55 % di alluminio del tipo Galvalume, Zincalume...*

*LA SUPERIORITA' DEL **GALFAN** rispetto al rivestimenti ricchi in alluminio (55 %) è dimostrata dalla prova di corrosione in atmosfera SO_2 realizzata su una lamiera deformata a seguito di una prova di imbutitura Erichsen.*

*Dopo 10 settimane, l'aspetto del **GALFAN** è rimasto immutato, mentre quello del Galvalume presenta una colorazione rossa a prova che l'acciaio è stato attaccato.*

GALFAN

Der kathodische Schutz ist eine typische Eigenschaft von Zink.
Er schützt Schnittflächen und durch Kratzer, Schrammen oder anders beschädigte Oberflächen.

Diese Eigenschaft wird wegen des geringen Aluminiumanteils (5 %) von **GALFAN** beibehalten, was bei anderen Überzugen wie Galvalume, Zincalume, usw. nicht der Fall ist.

Die Überlegenheit von **GALFAN** gegenüber aluminiumreichen Beschichtungen (55 %) wird durch den Korrosionsversuch in SO_2-Atmosphäre unter Beweis gestellt. Das Prüfblech wurde vorher einem Tiefziehversuch (Erichsen) unterzogen.

Zehn Wochen nach Versuchsbeginn war beim **GALFAN** keinerlei Veränderung festzustellen, während bei Galvalume eine Rotfärbung auftrat, welche bewies, dass das Stahlblech bereits angegriffen war.

GALFAN

BUONA VERNICIABILITA'

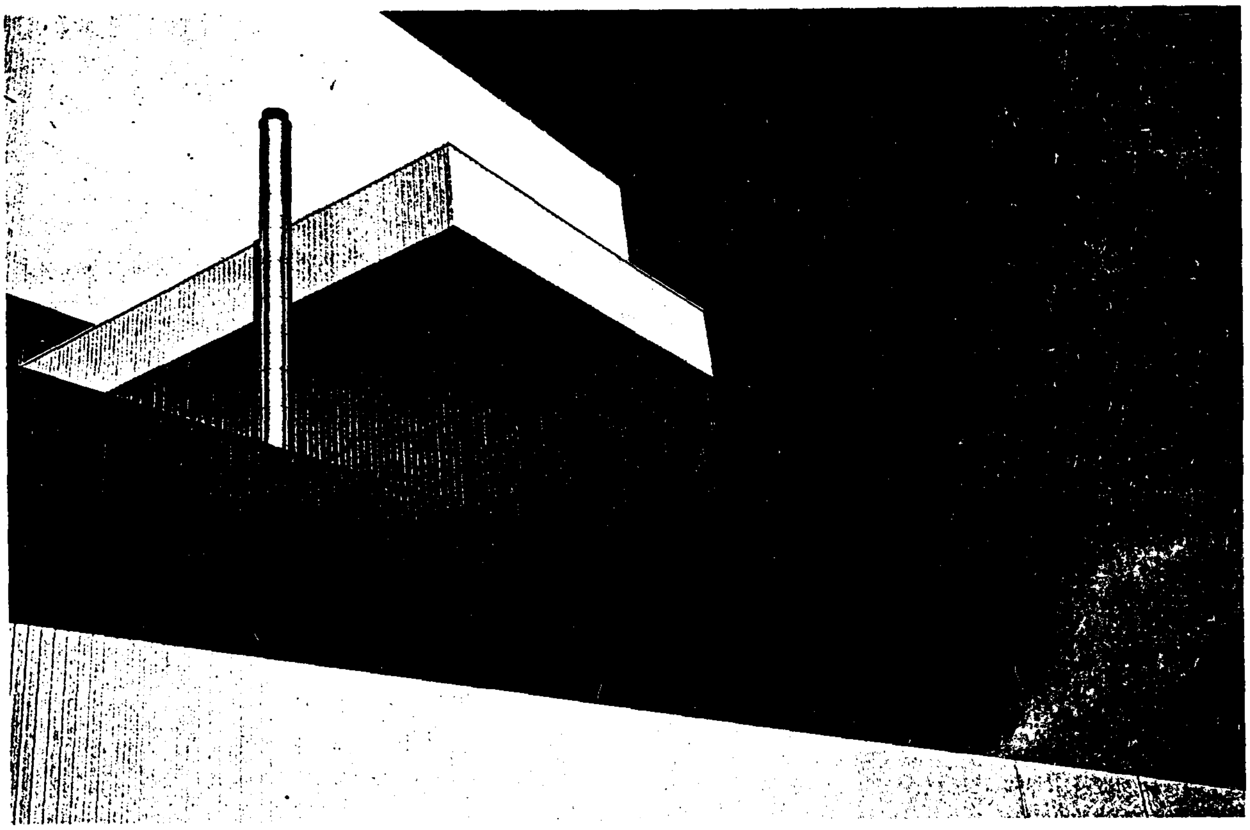
*Le lamiere **GALFAN** possono essere verniciate previo trattamenti adatti e finiture abituali.*

Nelle applicazioni dell'edilizia e degli elettrodomestici, si possono utilizzare diversi tipi di primer (epossidico ad acqua ad esempio) sui quali si può applicare una vasta gamma di vernici (Polyestere, PVC, acrilichi e plastisol). I primer speciali messi a punto nell'industria automobilistica possono anche essere applicati con successo.

GALFAN

Mit **GALFAN** verzinkte Bleche können mit den entsprechenden Vor-und Nachbearbeitungen grundiert werden.

Bei Verwendung im Baugewerbe und in der Haushaltsmaschinenindustrie können verschiedene Primärprodukte (z.B. Wasser-Epoxy) verwendet werden, auf welchen eine Deckbeschichtung (Polyester, PVC, Acryle und Plastisol) aufgetragen werden kann. Die spezielle für die Automobilindustrie entwickelten Primärbeschichtungen können ebenfalls erfolgreich appliziert werden.



PHENIX WORKS : Bardage Galfan / Galfan siding / [illegible] /

GALFAN UN EXCELLENT COMPORTEMENT A L'ÉTAT PEINT

Le comportement du **GALFAN** prélaqué est supérieur au galvanisé prélaqué lors de sollicitations importantes, car les propriétés de déformation du **GALFAN** n'engendrent aucune fissure susceptible de détériorer le film de peinture.

Les essais menés en atmosphère marine sur des produits prélaqués, sévèrement déformés, mettent en évidence la supériorité du support **GALFAN.**

GALFAN GOOD PERFORMANCE OF THE PAINTED PRODUCT

The behaviour of coil-coated GALFAN is better than that of coil coated galvanizing after severe deformation, because the properties of the GALFAN do not encourage the formation of cracks which would break down the paint film.

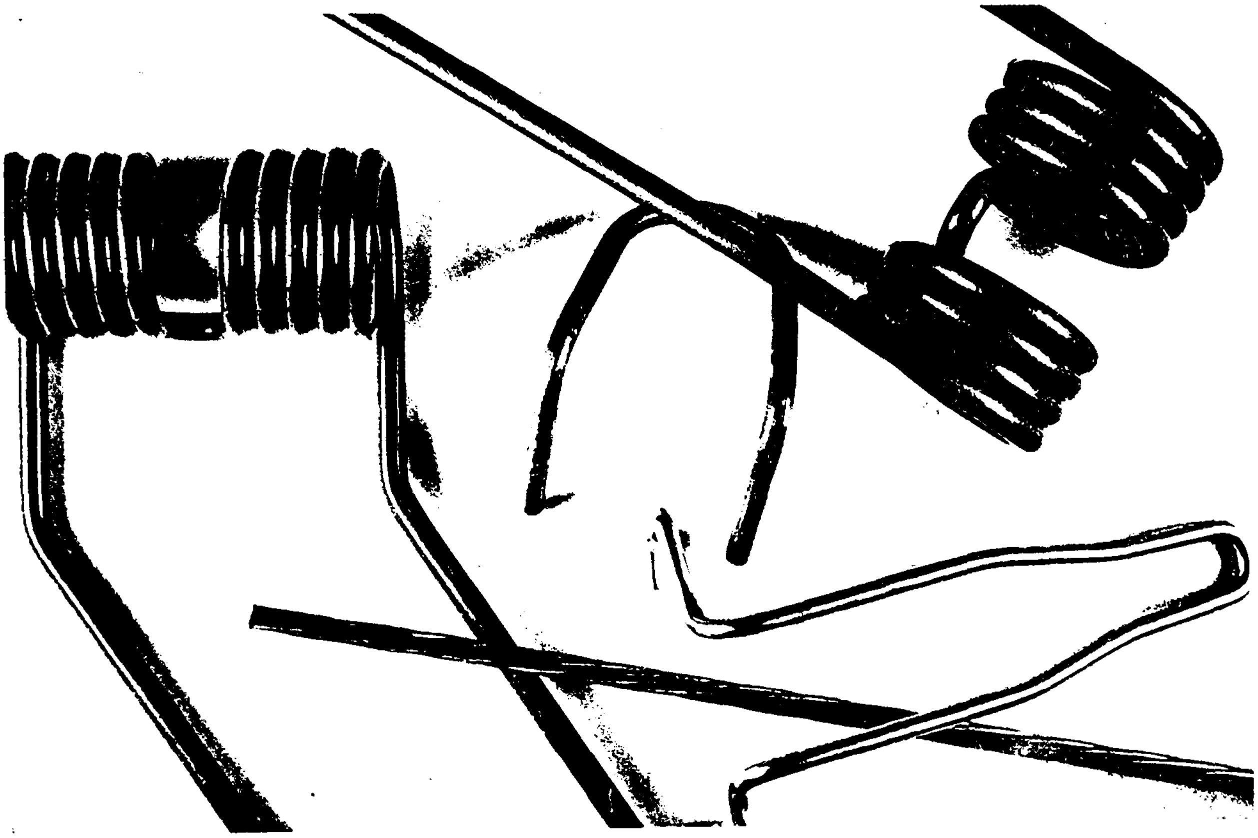
Experiments on severely deformed parts in marine atmospheres have shown the superiority of GALFAN as a substrate for paint'.

GALFAN COMPLÈTE LA GAMME DES REVÊTEMENTS ZINC DISPONIBLES SUR LE MARCHÉ

Le **GALFAN** est normalisé aux États-Unis ASTM B 750 et est en voie de l'être dans d'autres pays, notamment en France.

GALFAN COMPLEMENTS THE RANGE OF COMMERCIALLY AVAILABLE COATINGS

GALFAN is specified by ASTM B 750 in the United States, and specifications are being prepared elsewhere, notably in France.



FICAL : Ressorts / Springs / Molle /

GALFAN®
OTTIMO COMPORTAMENTO

*Quando è sottoposto a forti sollecitazioni il comportamento del **GALFAN** preverniciato è superiore a quello dello zincato tradizionale preverniciato, in quanto le proprietà di deformazione del **GALFAN,** non generano fessure suscettibili di deteriorare il film di vernice.*

*Le prove condotte in atmosfera marina su prodotti preverniciati, severamente deformati, evidenziano la superiorità del supporto **GALFAN.***

GALFAN®

Das Verhalten von vorgrundiertem **GALFAN** bei hoher Beanspruchung ist jenem von herkömmlich verzinkten Produkten deutlich überlegen, da die Duktilität von **GALFAN** die Rissbildung verhindert, welche die Beschichtung zerstören könnte.

Die in Meerklima an grundierten stark verbeulten Proben durchgeführten Versuchen ergaben ebenfalls eine deutliche Überlegenheit von **GALFAN.**

GALFAN®
COMPLETA LA GAMMA DEI RIVESTIMENTI ZINCATI DISPONIBILI SUL MERCATO

*Il **GALFAN** è normalizzato negli Stati Uniti con la norma (ASTM B 750) e sta per esserlo in altri paesi in particolare in Francia.*

GALFAN®

GALFAN ist in den Vereinigten Staaten unter der Norm ASTM B 750 standardisiert. In anderen Ländern, unter anderem Frankreich, ist die Standardisierung in Vorbereitung.

GALFAN®

Actuellement, 28 sociétés dans le monde possède la licence **GALFAN,** parmi lesquelles 22 produisent des tôles, 4 des fils et 2 des tubes.

At present there are 28 companies licensed to produce GALFAN, of which 22 are sheet producers, 4 are wire producers and 2 are tubemakers.

*Attualmente, 28 Società nel mondo possiedono la licenza **GALFAN,** di cui 22 producono lamiere, 4 fili e 2 tubi.*

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Pour tout renseignement concernant les performance **GALFAN** en bande et en fil et son approvisionnement, n'hésitez pas à utiliser le coupon réponse de l'un des centres de développement du zinc.

For all further information on the performance of GALFAN strip and wire, and availability please use the attached reply coupon and contact one of the zinc development centres.

*Per ogni ulteriore informazione riguardante le prestazioni del **GALFAN** in banda e filo e fornitura non esitate ad utilizzare il tagliando - risposta di uno dei Centri di sviluppo dello zinco.*

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HHH ELECTROCOATING CONDUCTOR ROLL

The field of continuous strip and wire plating has seen many technological advances through the years; new bath chemistry, high agitation rates, anode composition, high current density techniques, and instrumentation. One area stands out as having changed very little, that being the method of making contact with a moving strip or wire to apply the current used in the process. The normal method is to provide contact to a drum or commutator with brushes of a high metallic content. The commutator is connected to the shaft of a metallic roll, usually pressed or threaded onto the shaft. The current is carried through the shaft to the body of the roll and from the body of the roll to the strip passing over or under it. The roll is supported by bearings on the shaft of the roll. Many variations of this basic scheme have been used, such as the commutator in the form of a disc with the brushes radially pressing on it. In some cases the bearing itself carries current to the shaft of the roll.

In this process to be described, a novel approach to the problem of conducting current to the moving strip has been employed. This new system which will be referred to as an HHH Conductor Roll is described below. (Hirt et al. U.S. Patent Applied for "Method & Apparatus for Energizing Metallic Strip for Plating")

In this system a stator assembly is mounted in the plane of the moving strip, usually horizontal. The stator assembly carries a support member, copper conductors or bus bars, conductive contact shoes which also act as the bearings for the rotating roll, and cooling tubes if desired. Over this stator a tube of suitable metal, i.e. nickel, is placed and it becomes the only moving part of the roll. The tube is supported by the conductor shoes which also act as bearings. The tube is fitted with simple thrust collars and seal rings.

The tube has its inside diameter machined so as to present a good uniform bearing surface with clearance to slide over the stator. The conductor shoes are formed to the approximate diameter of the I.D. of the tube thus presenting a large bearing surface in the same area where the strip is pressed against the roll. This affords much less deflection of the roll as compared with conventional roller bearing supports outboard of the roll body. The stator assembly can be as rigid as is needed. There is no tendency for the roll to deflect on its stator.

The relatively large bearing area results in a very small unit loading.

HHH ROLL

The bearing area also acts as the conducting surface between the stator and the roll. The bearing shoes may be made of any suitable material, such as brass, bronze, or even conventional high metallic brush material. The shoes are bolted directly to copper conductor bars on the stator assembly to provide a solid copper path for the current from the external bus to the conductor shoes. This has very low resistance or voltage drop. From this solid copper path the current must travel across the rotating junction, whose area we have said is large, thus giving a low contact current density, and then through the wall thickness of the tubular roll to the moving strip. A comparison of the resistance values follows:

Where R_{buss} = Resistance of solid path copper buss.

R_{brush} = Resistance of brush material

$R_{junction}$ = Resistance of moving contact

R_{shaft} = Resistance of roll shaft

$R_{roll\ body}$ = Resistance of roll body to strip

1. Conventional Roll R_{bus} = HHH Roll R_{bus}

   No real difference should be expected in the resistance of the solid copper current path.

2. Conventional Roll $R_{brush} = X$ HHH Roll $R_{brush} = Ø$

   Inasmuch as the HHH Roll has no brushes, leads, or brush holders the resistance is zero.

3. Conventional Roll $R_{junction} >$ HHH Roll $R_{junction}$

   The resistance of the HHH junction is less due to the relatively large area, plus the loading from the line strip tension acting to apply pressure on the junction to provide a more intimate contact.

4. Conventional Roll $R_{shaft} = Y$ HHH Roll $R_{shaft} = Ø$

   As no current is carried by a shaft in the HHH Roll, the resistance is zero.

5. Conventional Roll R_{body} > HHH Roll R_{body}

In the HHH Roll the current travels only through the thickness of the shell, while in a conventional roll with the current applied from the ends, it must travel the distance to the strip.

These relations were borne out in experimental trials where the voltage drops were measured from the external buss to the rotating surface of the roll, comparing an HHH roll to a conventional roll having commutators, brushes etc. The total voltage drop in the HHH Roll was approximately one half of that found in the conventional roll. (30 to 32 millivolts drop for the conventional roll vs. 14 to 15 millivolts drop for the HHH Roll carrying the same current.)

It is also interesting to note that the contact current density was about the same for the two rolls, with the conventional roll having a large number (36) externally mounted brushes, while the HHH roll had only the two conductor bars or internal shoes.

This conventional roll with bearings inboard of the commutator drum was found to require about 37 foot pounds of torque to turn the roll. Most of this torque requirement was to overcome the friction of the brushes, springs, etc. The HHH Roll required only 4 foot pounds to turn the roll. While it is possible to drive the HHH Roll either by a belt or on overrunning gear, this low inertia will permit friction driving the roll by the strip itself in many cases.

The stator design permits internal cooling by water or other coolant, and the direct cooling of the moving junction may be accomplished by drilling the stator to permit water flow to that area. The lower resistance of the HHH roll may in some cases make water cooling unnecessary.

The atmosphere around a strip plating line is somewhat corrosive. In the case of a conventional roll this makes for poor contact between the brushes and commutator and potential bearing problems. The HHH design, having the bearing and commutator within the sealed roll body keeps the load bearing and current carrying elements protected from the corrosive

Temperature sensors may be imbedded in the stator to control cooling water flow, or to warn of a malfunction.

In summary, the HHH design has the following advantages when compared to a conventional contact roll:

1. Eliminates costly roller or ball bearings.
2. Reduces frictional drag due to lower rotating torque.
3. Lowers electrical resistance between bus bar and strip.
4. Lowers heating of the roll due to lower resistance.
5. Eliminates brush maintenance.
6. Simple stator design permits water cooling if desired by rigid piping, rather than through rotary unions, etc.
7. Bearing and commutator surfaces are protected from corrosive environment.
8. Rigid design provides less deflection.
9. Lower cost by elimination of conventional bearings, brushes or brush holders.
10. Lower maintenance.
11. Higher voltage efficiency which will result in lower power cost.
12. Can be used in horizontal or vertical position and also can be positioned as a cantilevered/conductor roll.

T. A. Hirt,
Consultant
Continuous Strip Electroplating

Attachment: Dwg. 9310-101

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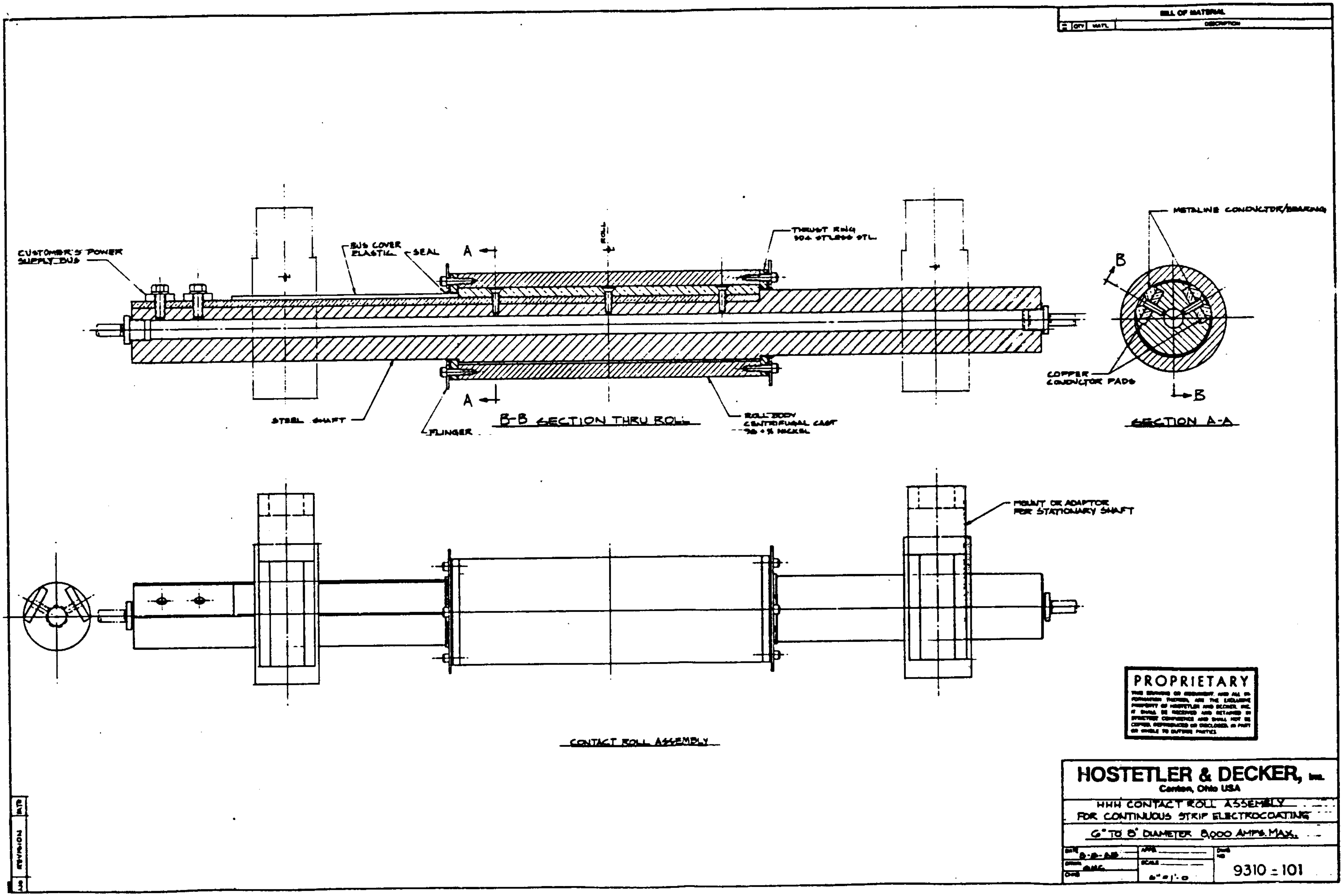
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REVISION

Producing ASTM A446 Grade E GALFAN-Coated Sheet with Superior Formability

I. Introduction

The production of galvanized or coated ASTM A446 Grade E (full hard) is difficult. In order to retain "full hard" properties, the annealing furnace must be cooled to 500°C. from normal operating temperatures in the neighborhood of 800°C. This results in production losses at start-up and shut down.

Because of the low furnace temperatures, coating adherence can be a serious problem.

Sheet produced with full hard properties has limited formability.

II. Production of GALFAN-Coated "Full Hard" Sheet by Conventional Practice

In Liege, Belgium, in 1985, Mr. Takusari, Kawasaki Steel, Japan, presented a paper describing their production techniques for achieving quality GALFAN-coated Grade E material.

Strip reduction heating temperature was set at 500°C. with a bath temperature of 480°C.

Typical properties were achieved in the strip and the coating was virtually free of defects, and the corrosion resistance was excellent.

III. Production of ASTM A446 Grade E GALFAN-Coated Sheet by the ZINQUENCH Process

A. Dual-Phase Steel

During the second ZINQUENCH production trial carried out at Ziegler (Mouzon), May 5 and 6, 1986, one of the many steel compositions processed was as follows:

C - %	Mn - %	Si - %	thickness
0.10	1.3	0.4	0.7 mm

The average thermal cycle, annealing and quenching, is shown in Figure 2.

- Annealing temperature - 800°C.
- Quenching from 650°C. 1202
- GALFAN bath temperature - 410°C. 770

Mechanical properties of the resulting strip without stretch-levelling (SKP - 0%) are shown in Table 1.

Table 1

Properties of the Strip
(SKP - 0%)

Yield Strength	300 MPa
Tensile Strength	740 MPa
Elongation	28% - A_{50}
Coating Thickness	25µm/25µm

The GALFAN coating was very good with excellent adhesion, no craters or uncoated spots with fine grain-size.

B. Stretch-Levelling of Dual-Phase Steel

It is well know that the yield strength of dual-phase steels increase almost lineaily during stretch levelling operations. These data are shown in Figure 3.

The dual-phase structure in the presence of hard second phases generates very high work hardening rates with small deformations.

Based on this fact, the percentages of work hardening realized in stretch levelling can readily achieve the desired yield strength levels. In Figure 4, the change of dual-phase steel's yield strength and elongation produced by the ZINQUENCH Process employing various degrees of stretch levelling, are presented.

Thus, from one steel alone, it is possible to produce ALL the grades of ASTM A446 as shown in Table 2 and Figure 5.

Table 2

Characteristics of the Steel
with Different SKP

Grade	Requirements	SKP	Mechanical Properties
A	228/310/20%	0%	300/740/28%
B	255/359/18%	0%	300/740/28%
C	276/380/16%	0%	300/740/28%
D	345/448/12%	0.5%	360/740/27%
F	390/483/12%	1.0%	410/740/25%
E	550/565/---	~ 2.5%	560/740/18%

A very major improvement in formability of Grade E is achieved as compared to conventionally produced "Full-Hard" Grade E sheet as shown in Table 3.

Table 3

Properties of the Strip
(SKP $\simeq$ 2.5%)

	ZINQUENCH Produced	Conventionally Produced	ASTM A446 Grade E
Yield Point	560 MPa	660 MPa	550 MPa
Tensile Strength	740 MPa	670 MPa	570 MPa
Elongation - A_{50}	18%	7%	---

IV. Economics of Production

A comparison of the economics of producing Grade E by the ZINQUENCH Process and conventional technology is shown in Table 4.

Table 4

Economic Comparison of ZINQUENCH versus Conventional Technology

	Conventional	ZINQUENCH	Remarks
Bath Temperature	(-) 480-500°C.	410°C.	( ) - Fe in bath - bath equip. corrosion
Annealing Temperature (cleaning of strip)	(-) max.500°C. (poor)	800°C. (good)	- cooling of furn. 800 → 500°C.
Coating - Quality	(-) poor adhesion	100%	- rejections/ scrap - poor adhesion - grain-size
Steel: Mechanical Properties (Elongation)	7%	(+) 18%	+ new applications
YIELD - %	(-) rejections -production difficulties	see note below *)	- production losses in start-up

*) Note: The only uneconomical feature of the ZINQUENCH Process is a higher energy consumption due to a higher annealing temperature as shown in Figure 6, but the production losses and the low yield of conventional processing are of greater significance.

V. Conclusions

A. All of the requirements of the various grades of ASTM A446 can be realized employing the ZINQUENCH Process and using steels containing 0.1% C. and 1.3% Mn., developing final properties by cold working, i.e., stretch-levelling.

B. Stretch-levelling of about 3% provides the minimum required yield strength (550 MPa) for Grade E.

C. After stretch-levelling, ZINQUENCH material retains a ductility of 18% as compared to the ductility of conventionally produced material at 7% elongation.

D. Conventional processing requires cooling the annealing furnace from 800°C. to 500°C. ZINQUENCH requires no cooling and loss of production during the cooling and reheating cycles.

E. The GALFAN coating produced by ZINQUENCH processing is superior to conventionally produced GALFAN coatings with respect to surface defects, appearance, porosity, grain size and smoothness, yet retaining excellent adherence, ductility and corrosion resistance.

F. The simplicity of ZINQUENCH processing assures low operating costs, uniformity of product, superior forming properties and maximum product recovery (low scrap losses).

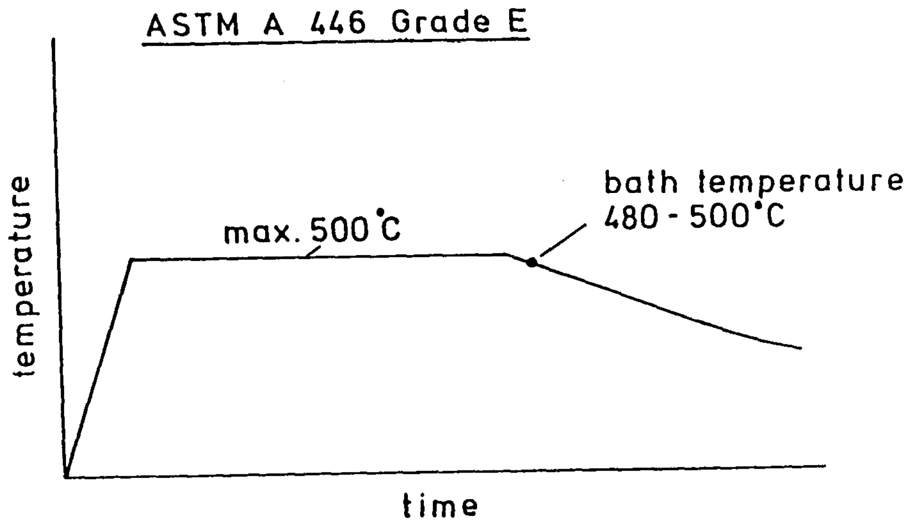

FIGURE 1. GALFAN-Coated Grade E sheet by Conventional Cycle

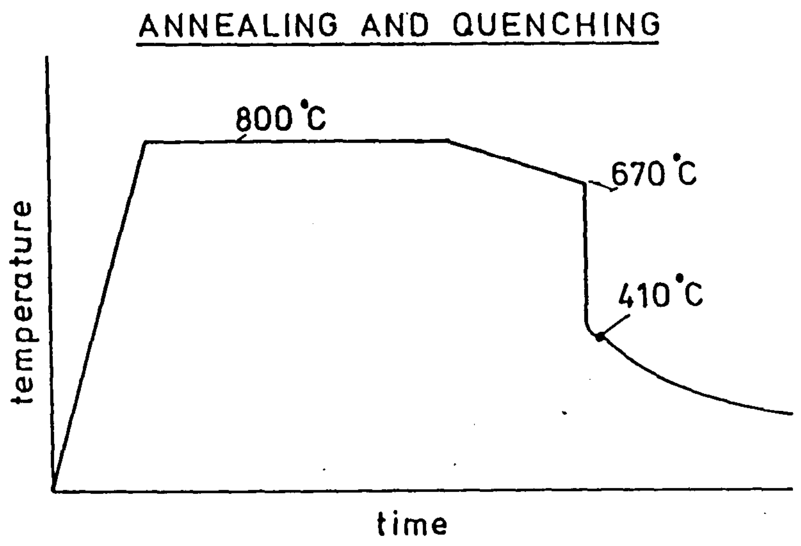

FIGURE 2. The Thermal Cycle by the ZINQUENCH Process

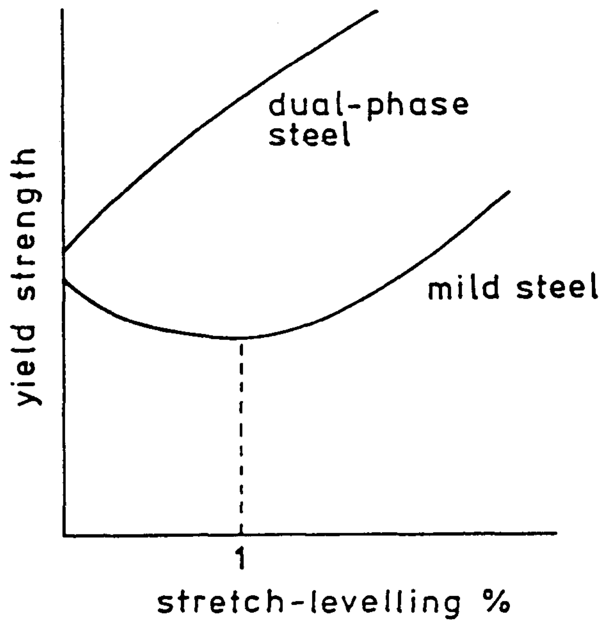

FIGURE 3. The Yield Strength of steels after different Stretch-Levelling Operations.

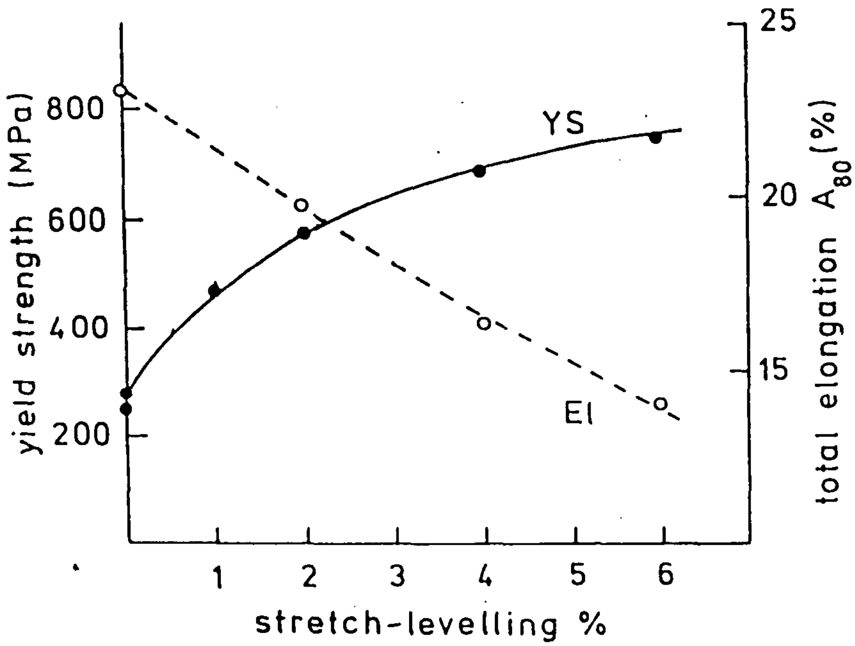

FIGURE 4. The Change of Dual-Phase Steel's Yield Strength and Elongation employing various Degrees of Stretch-Levelling.

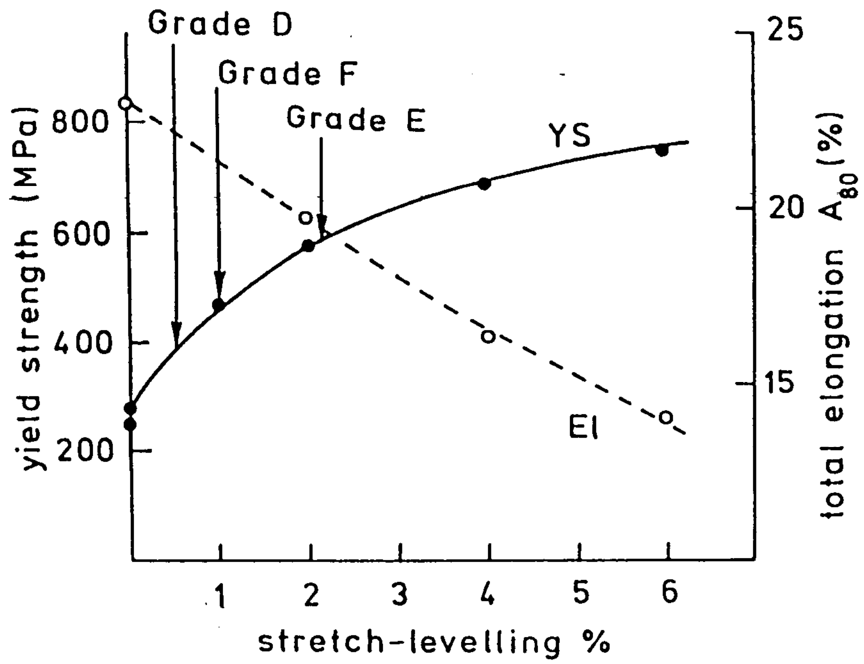

FIGURE 5. To produce, from one steel, ALL the Grades of ASTM A446.

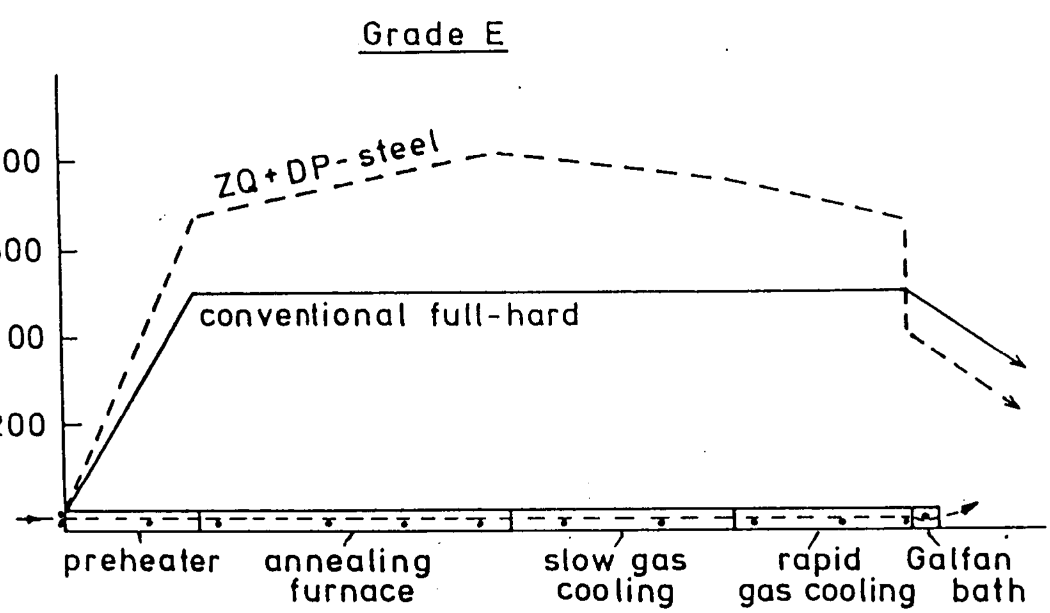

FIGURE 6. The Thermal Cycles of the Conventional and the ZINQUENCH Practices.