INTERNATIONAL LEAD ZINC RESEARCH ORGANIZATION, INC.

GALFAN TECHNICAL RESOURCE CENTER

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MEMORANDUM

TO: GALFAN Process Licensees
GALFAN Alloy Licensees
GALFAN TRC Sponsors
GALFAN Suppliers
Dr. Rolf Nunninghoff, University Wuppertal/ARBED
Dr. V. Leroy, CRM
Dr. R.F. Lynch, Lynch & Associates, Inc.

FROM: Marshall P. Roman MPR

DATE: 23 July 1990

SUBJECT: Fifteenth GALFAN Licensee Meeting Minutes

Enclosed please find the subject minutes. Included is a brief summary of the plant tour of Cockerill-Sambre/Branche PHENIX No. 7 CGL.

Please note the updated GALFAN tonnage figures and forecasts for 1989 and 1990. The total GALFAN tonnage for 1989 was 229,109 tons, with a 1990 forecast increase of 26% at 288,672 tons. Total cumulative GALFAN tonnage should approach the 900,000 ton mark by the end of 1990.

Please also note that there has been no definite site decided upon for the next GALFAN Licensee Meeting, which probably will be held in May or June of 1991.

Also, enclosed please find attached to this memo, a description of "GALVATECH '92." The conference scheduled for September 1992 will be organized by CRM in collaboration with Hoogovens IJmuiden. The conference will take place in Amsterdam. Please note that ILZRO is a sponsor for the GALVATECH '92 conference in a capacity of providing information to interested parties.

MPR/ja

Attachments

GALVATECH'92

THE SECOND INTERNATIONAL CONFERENCE ON ZINC AND ZINC ALLOY COATED STEELS WILL BE ORGANIZED BY C.R.M. FROM 8 TO 11 SEPTEMBER 1992 IN AMSTERDAM WITH THE COLLABORATION OF HOOGOVENS IJMUIDEN.

FOLLOWING GALVATECH'89 IN TOKYO, THIS CONFERENCE WILL EXAMINE CURRENT AND NEW DEVELOPMENTS IN THE IMPORTANT FIELD OF STEEL COATINGS.

SCOPE

THE PAPERS AND DISCUSSIONS WILL CONCENTRATE ON THE FOLLOWING TOPICS :

- PRODUCTION TECHNOLOGY : METALLIC COATINGS
  ORGANIC COATINGS
- STRUCTURAL AND SURFACE CHARACTERIZATION OF COATINGS
- NEW PROCESSES - NEW COATINGS
- APPLICATIONS : AUTOMOTIVE
  WHITE GOODS - APPLIANCES
  BUILDING

PLANT VISITS

PLANT VISITS WILL BE ORGANIZED AT THE END OF THE TECHNICAL CONFERENCE.

VENUE

HOTEL KRASNAPOLSKY, AMSTERDAM, THE NETHERLANDS.

CONFERENCE SECRETARIAT

C.R.M.
RUE E. SOLVAY, 11, B - 4000 LIEGE (BELGIUM)
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Fifteenth GALFAN Licensees Meeting

5-7 June 1990

Holiday Inn/Palais des Congres
Liege, Belgium

5 JUNE 1990 SESSION

ATTENDANCE:

Name	Company
Baker, A.	New Zealand Steel
Blondeau, J.	SOLLAC
Bourgeois, P.	Galvameuse (France)
Brinsky, J.	Weirton Steel Corporation
Brugarolas, J.	Procoat, S.A.
D'Autilia, A.	ICMI - Italy
Dewitte, M.	N.V. Bekaert
Donnay, L.	Cockerill Sambre/Branche PHENIX
Dubois, M.	Cockerill Sambre/Branche PHENIX
Ehlers, K.	Stahlwerke Peine-Salzgitter
Faderl, J.	Voest-Alpine
Fukushima, Y.	NKK
Gailliez, B.	F.F.M. (France)
Goodwin, F.	ILZRO
Haines, C.	Pasminco Europe
Hennechart, J.	SOLLAC
Hirose, Y.	Nisshin Steel
Hogan, J.	Brailsford Wire Supply Ltd.
Hook, G.	New Zealand Steel
Hosoya, G.	Yodogawa
Hostetler, J.	John Hostetler PE, Inc.
Hudok, D.	Weirton Steel Corporation
Jenkins, A.	British Steel
Kinnunen, J.	Rautaruukki Oy
Kubiak, B.	Metaleurop SA (France)
Lamberigts, M.	CRM
Leroy, V.	CRM
Lynch, R.	Lynch & Associates, Inc.
Mathieu, S.	SOLLAC
Matthews, A.	British Steel

5 JUNE 1990 SESSION (contd.)

Name	Company
Mossgrove, D.	Weirton Steel Corporation
Moulin, J.	ARBED-Research
Nishimura, G.	Noranda Sales
Nunninghoff, R.	University of Wuppertal
Oishi, H.	Sumitomo
Ottersbach, W.	Mannesmann Demag
Parrish, D.	Wheeling-Pittsburgh Steel
Payne, D.	Bridon Ropes
Pierre, M.	Centre du Zinc (France)
Rodellas, F.	Procoat, S.A.
Rollez, D.	Vieille Montagne
Roman, M.	ILZRO
Romu, K.	Rautaruukki Oy
Sambuco, E.	Wheeling-Pittsburgh Steel
Schwarz, W.	Hoesch Stahl AG
Silvestre, A.	Cockerill Sambre/Branche PHENIX
Skenazi, A.	Vieille Montagne
Sugimoto, T.	Nippon Denro
Szydlik, A.	Stahlwerke Peine-Salzgitter
Takeda, K.	Nippon Denro
Tsuji, K.	Kobe Steel, Ltd.
Wegria, J.	Vieille-Montagne

INTRODUCTION:

Mr. Marshall P. Roman, Director of the GALFAN Technical Resource Center, ILZRO, Inc., U.S.A. welcomed all the attendees to Liege for the *Fifteenth GALFAN Licensees Meeting*. He apologized for all of the changes that went into the organization of the meeting and hoped that all attendees had had good travel. Mr. Roman briefly noted that there were two new licensees since the Helsinki Meeting of July 1989. Those were Caledon Tubing of Mississauga, Ontario, Canada, and ITT-Higbie Automotive Group of Auburn Hills, Michigan, U.S.A. Mr. Roman asked all the attendees to introduce themselves after which he introduced Dr. Richard F. Lynch of Lynch and Associates, U.S.A.

Dr. Lynch spoke briefly about the proposed formation of GALFAN International, Inc. (GI Inc.). Dr. Lynch has been negotiating with ILZRO for the purchase of the GALFAN patent rights and patent estate. Dr. Lynch explained the reasons why ILZRO was interested in selling the GALFAN patent rights and he gave his reasons for wanting to purchase those patent rights. ILZRO felt that the formation of GALFAN International would be the most advantageous from the standpoint of marketing GALFAN and developing GALFAN into a major product in the coated sheets field. Since negotiations were still ongoing at that time, Dr. Lynch could not go into any further details.

RESEARCH SESSION

Mr. Roman introduced Dr. Y. Hirose of Nisshin Steel who acted as the session chairman.

CRM Research Report:

Dr. Hirose introduced Mr. Marcel Lamberigts of CRM who reviewed the past year's work on ILZRO project ZM-285 (GALFAN). This was the work which has been summarized in Progress Report 21. The bulk of Mr. Lamberigts report is reproduced in the appendix to these minutes.

Main Headings of Topics Covered Are:

Accelerated Cooling: Mr. Lamberigts discussed the structural evolution of GALFAN with some emphasis on the possible effect of steel substrate. There was some detailed explanation of corresponding corrosion properties. There were slides and discussion on the effect of cooling rate on GALFAN microstructure as well as comparisons of the effect of air flow and water delivery. Also covered was the effect of the cooling rate on the GALFAN surface conditions. Other discussions centered on the effect of accelerated cooling on cell size as well as its effect on grain boundary depth.

It was noted that an interesting result occurred when switching from Al-killed to IF (interstitial-free) steel. The finished surface of the GALFAN coated steel became much smoother with the use of the IF substrate. It was found that with the use of IF steel substrates, the grain boundary dent depths were lower, although the cell sizes were the same as that of the Al-killed steel substrates.

Intercellular Corrosion: This problem has been investigated in the last year by examining how aluminum diffuses within the GALFAN coating. Samples have been soaked in pure oxygen, dry argon, and exposed to 100% humidity at 40°C for approximately 30 days. The segregation of aluminum and oxygen within the coatings has been examined utilizing coating weights of 50 and 250 g/m^2. No iron enrichment after these exposures has been seen. After exposure in pure dry argon, very small traces of aluminum enrichment around the zinc particles is seen. Aluminum concentrations did not diffuse significantly after 30 days in pure oxygen and in dry argon. A significant change is seen after exposing the samples to 100% humidity. Large grain boundary defects and corrosion around zinc-rich particles is seen. Also, regions within the eutectic are observed to corrode. Intercellular corrosion appears wherever concentrations of pure aluminum are seen in the microstructure. The aluminum tends to sacrificially corrode when coupled with either the eutectic or zinc-rich particles, therefore it appears that aluminum is a strong anode in a humid environment for GALFAN.

Formability: These studies utilized samples commercially roll formed during 1988 by ILZRO at H.H. Robertson (USA), and subjected to corrosion testing. In all cases, on painted roll formed GALFAN performed far better than conventional unpainted roll formed galvanized steel. It was also found that GALFAN has very limited edge creep compared to normal galvanized steel. The best performance was seen with the GALFAN that was extra smooth (temper rolled), chromated, and oiled. An ongoing problem is seen to be that of defining ductility in a quantitative sense. In most cases regarding GALFAN and galvanized, it is an objective judgement based on visual observations as to whether a part can be made. Mr. Lamberigts noted that he would appreciate receiving more material from the U.S. and Japan as well as Europe. Mr. Lamberigts also noted that he was certainly open to receive input on other test methods for quantifying ductility.

Soil Burial: Mr. Lamberigts briefly reviewed the CRM soil burial exposure program. Samples of GALFAN, Galvalume, and aluminized as well as conventionally galvanized steel (chromated and unchromated) have been buried since 1984 at four sites; a garden with black soil, an agricultural area with sandy yellow soil, an orchard, and a motorway that has road deicing salt exposure. Both 3-year and 6-year exposure results are now available. GALFAN is performing very well in the black soil after 3 years with the notation that a bluish color is observed. All other samples have white and red rust spots. Red rusting is particularly notable on Galvalume. No red rust is seen on galvanized. A similar pattern is seen for the orchard samples with the notation that the panels do not seen to deteriorate as quickly as in black soil. After 6 years in the sandy yellow soil, the GALFAN panels are in very good condition (it should be noted that chromated Galvalume from ARBED appears very good in the sandy yellow soil, while non-chromated Galvalume from Bethlehem Steel was in very poor condition). The motorway samples (6 years) showed that GALFAN looked to be in excellent condition while all other samples had red rust. Mr. Lamberigts also noted that with regard to soil burial, there is the market of culverts or under motorway pipes for GALFAN as a possible substitute for concrete.

Mr. Parrish of Wheeling-Pittsburgh Steel noted that they had some hot roll pickle and oiled steel coated at Weirton Steel which is now under evaluation and he noted that it could be possible for Wheeling-Pittsburgh to supply samples for study. Dr. Lynch noted that in North America, corrosion performance of culverts, while important, is secondary. The first concern is erosion due to gravel, stones, and water. Mr. Austin Matthews of British Steel asked if the gray patina of GALFAN has any effect on corrosion performance. Mr. Lamberigts noted the effect is positive since metallurgically, gray patina is a protective oxide barrier.

Mr. Leroy of CRM asked a question directed to Wheeling-Pittsburgh, what was the steel grade of the culvert material? Mr. Parrish noted that it was a commercial quality mild carbon steel substrate. Mr. Leroy asked why a high-strength steel could not be used in order to reduce the thickness. Mr. Sambuco of Wheeling-Pittsburgh noted that it was very difficult to roll form high-strength steel into the corrugated shape necessary in the culvert application. Dr. Lynch also noted for the record that GALFAN is now facing competition with aluminized steel culvert material and he expects it to be an uphill battle because U.S. Army Corp of Engineers has given aluminized steel very good grades, thanks largely to Armco Steel, a larger producer of aluminized steel.

Mr. Lamberigts continued with his presentation:

Magnesium Additions: Mr. Lamberigts noted that there appeared to be no advantage of magnesium-containing GALFAN over magnesium-free GALFAN with regard to corrosion resistance, however in all cases accelerated cooling improved ductility. There was the observation that higher magnesium contents in GALFAN result in finer and more numerous cracks than for samples with low magnesium contents. Any improvement in corrosion resistance in magnesium-containing GALFAN would probably be seen by increasing the coating thickness (caused by increased alloy viscosity) rather than improving solely due to the magnesium content.

Heavy Gauge GALFAN: Mr. Lamberigts reviewed this program, noting that there is not a great deal of new information available. As is the case with all GALFAN, accelerated cooling improves corrosion resistance. Other notations are: as iron loss increases (diffusion of iron into the bath due to extended bath residence times), ductility decreases. That is, the number of cracks increase. Also, the addition of silicon in the GALFAN bath reduced the iron loss. Silicon keeps iron loss low no matter what the bath temperature is, i.e., if there is no silicon addition, the iron loss increases with the rise in bath temperature. Silicon keeps the number of cracks low no matter what the bath temperature is, that is, if no silicon the number of cracks increase with the increase in bath temperature.

Austin Matthews noted that he is of course pleased with the research performed by CRM but he wanted to make his point known that he is still unsure as to what is the "real" GALFAN. He wants to know, as do many licensees, what the fixed composition of GALFAN should be, rather than many performances at many compositions. Mr. Lamberigts agreed that such a fixed composition was necessary, however he was just showing the positive effects of silicon additions. Dr. Lynch interjected noting that according to ASTM B750 silicon additions are limited at .015 weight percent. The point being that although agreeing with Mr. Matthews, the potential positive and negative effects of different compositions should be studied.

Mr. Faderl of Voest-Alpine asked what was the steel grade of the substrate for the heavy gauge material. Mr. Lamberigts noted that it was the same as for the earlier material. Mr. Lamberigts also added that the thickness of the intermetallic was 20-25 microns. Dr. Hirose asked if there were any deleterious effects of the silicon additions. Mr. Lamberigts replied that since CRM was working within the ASTM specification, he had observed no deleterious effects. Dr. Goodwin added that all the attendees present should refer to the 1986 CRM progress report which lead to the development of ASTM B750, the GALFAN alloy ingot specification.

Ms. Mathieu of SOLLAC asked if Mr. Lamberigts looked at the corrosion performance of GALFAN with respect to the silicon additions. Mr. Lamberigts replied that he did not but felt that that would an interesting topic for further study.

Mr. Lamberigts continued with his report.

Coil Coating: Mr. Lamberigts described the sulfur dioxide (SO_2) cyclic tests that utilized Nisshin Steel and Hoesch Stahl prepainted GALFAN samples. Mr. Lamberigts noted that Nisshin prepainted GALFAN out-performed Nisshin prepainted galvanized steel. Also, Mr. Lamberigts stated that Hoesch Stahl prepainted GALFAN out-performed Hoesch Stahl prepainted galvanized steel. It was also noted that over-baking of the paint topcoat was observed to improve overall corrosion performance. Paint baking slows down penetration of corrosive solutions through the topcoat to the coated substrate.

Overall Corrosion Performance: Mr. Lamberigts quickly reviewed the results of material sent to Dr. Hirose of Nisshin Steel. Mr. Lamberigts noted that he did not want to overlap reports with those of other licensees, so he decided to keep his presentation as brief as possible. Mr. Lamberigts noted that GALFAN still is performing as well as or better than previously reported, i.e. GALFAN is still maintaining superiority of two to three times better corrosion resistance than conventional galvanized steel.

Nisshin Steel Report:

Dr. Hirose reviewed results of Nisshin Steel's seven-year test results of GALFAN and galvanized. The report is reproduced in its entirety in the minutes appendix. Briefly summarized, Dr. Hirose noted that GALFAN is better than was first expected. According to his Figure 6, he noted his exposure sites were the following: severe marine-Okinawa; marine - Choshi; industrial - Nagasaki; rural - Kiryo.

He noted that he has confirmed the previously observed phenomena that galvanized corrosion is linear, whereas GALFAN corrosion appears to be parabolic, that is, the rate of corrosion slows down with time. Basically as has been observed previously, the corrosion of GALFAN and galvanized look similar for a year or two, but then the passivation of GALFAN slows down the corrosion rate therefore resulting in superior performance.

After seven years, Dr. Hirose noted the following corrosion resistant ratios: (superiority of GALFAN over galvanized):

Environment	Corrosion Resistance Ratio
Rural	2.04
Industrial	2.07
Severe Marine	2.16

Dr. Hirose noted that according to his studies, he expects the above-listed ratios to improve since the corrosion of GALFAN appears to be parabolic compared to the linear corrosion of galvanized.

Dr. Lynch noted for the record that it is very good to see the corrosion resistance of sheet is corresponding to the observed corrosion resistance of wire (presented at Interwire '89, Atlanta, Georgia, U.S.A., November 1989), that is, after three years of outdoor exposure on wire, the same phenomena was observed. For one or two years, GALFAN and galvanized look similar but then the linear relationship of galvanized was observed along with the parabolic relationship for GALFAN.

New Zealand Steel Report:

Mr. Gary Hook and Mr. Alan Baker presented the results of 8 and 9 year long-term outdoor exposure on bare and prepainted GALFAN at New Zealand Steel. This report is reproduced in its entirety in the minutes appendix. Mr. Hook noted that material tested was some of the first ever-produced GALFAN made by Ziegler (now SOLLAC) at the Mouzon trial of 1981. This material, both bare and prepainted (painted in laboratory), was exposed on the Manakau Heads site on the west coast of New Zealand (North Island).

Mr. Hook showed several slides showing the superior performance of GALFAN over galvanized for both bare material and prepainted material. It was New Zealand Steel's observation that GALFAN was performing three times better than that of galvanized according to weight losses (it was observed that GALFAN was losing an average of 5 g/m^2 per year whereas zinc was averaging 15 g/m^2 per year loss).

Sumitomo Metal Industries Report:

Mr. H. Oishi presented the SMI report, "Corrosion Behavior of GALFAN Steel Sheets at Edge Portion." This report is reproduced in the minutes. The major conclusion reached in this report is that GALFAN has excellent edge corrosion properties, in fact, it had the best edge corrosion properties with respect to galvanic cathodic edge protection compared to galvanized and Galvalume, especially as the cut edge becomes thicker (i.e. heavy gauge steel).

Dr. Goodwin asked Mr. Oishi, for the cyclic corrosion tests, how long was one cycle. Mr. Oishi replied that one cycle equals one day. Dr. Goodwin then added that according to the experimental procedure, he wanted to know how high the voltage was since that at high voltages it is possible to break down the passivation layer of GALFAN and therefore invalidate the results. Mr. Oishi was not sure and could check this for Dr. Goodwin but he felt that it was no higher than 50 millivolts (mV). Dr. Goodwin then noted that such a low voltage would not be enough to break down GALFAN's passivation layer.

NV Bekaert S.A. Report:

Dr. Marc Dewitte presented his report entitled "A New Generation of Corrosion Protective Coating." He noted that this report was given at Interwire '89 in Atlanta, Georgia, U.S.A., November 1989 as well as Wire '90 in Dusseldorf, April 1990. The report is reproduced in the minutes of the report (and also appeared in the May 1990 issue of Wire Journal).

Some of the highlights of the report are: with wire, Dr. Dewitte noted that Bekaert tries to stay near the eutectic (5.2% aluminum) point of GALFAN as opposed to some of the lower aluminum seen with the sheet reports. So, Dr. Dewitte feels that with GALFAN wire one can obtain the best of both (aluminum, zinc) worlds. One has the concentration of aluminum (oxides) concentrated on the surface for excellent corrosion resistance, as well as the excellent galvanic cathodic protection of a high zinc coating. One highlight that Dr. Dewitte emphasized was the superior performance of welded GALFAN wire as compared to welded wire that was then batch dip galvanized. Even with a lighter GALFAN coating that has been compromised at a weld, the GALFAN performed (overall) better than the batch dipped (heavier coating) galvanized prewelded wire. GALFAN showed no rust at the welds whereas the batch dipped galvanized wire did.

University of Wuppertal Report:

Dr. Rolf Nunninghoff presented, on behalf of ARBED, his report on GALFAN wire. This report is also reproduced in the appendix of the minutes. Some highlights of the report are: in general, Dr. Nunninghoff agrees with Dr. Dewitte, especially on the point of superior performance of welded GALFAN wire over that of batch dip galvanized welded wire. Dr. Nunninghoff wanted to emphasize the excellent performance of GALFAN in the marine environments as well as in all standard cyclic tests. One major application that Dr. Nunninghoff highlighted was the superior performance of GALFAN wire for mining ropes. One has a very corrosive atmosphere of high moisture, high humidity, heat, and usually high SO_2 concentrations. GALFAN wire out performs galvanized wire with respect to corrosion resistance as well as with respect to mechanical tests. He noted that galvanized wire, rope usually lasted 5 to 13 months in a mine, whereas GALFAN wire rope has already lasted greater than 24 months. Dr. Nunninghoff also noted that the higher hardness of GALFAN wire was better for abrasion resistance.

Mr. Parrish of Wheeling-Pittsburgh Steel asked Dr. Nunninghoff what was the cost differential between GALFAN and galvanized. Dr. Nunninghoff replied, noting that he was a research scientist and not a marketing expert that he felt that the cost of GALFAN may be 5-10% higher, however he noted that one can obtain at least double the life with GALFAN wire. Mr. Hogan interjected, noting that as a one time agent for FICAL (now TrefilUNION) one can get a 20-25% price premium, whereas the actual production cost may only be 5% higher. It is quite profitable to produce GALFAN in wire or sheet form. Dr. Schwarz of Hoesch Stahl asked how Dr. Nunninghoff measured the weight loss on his GALFAN wire. Dr. Nunninghoff noted that it was a weigh-strip-weigh method, utilizing a hydrochloric acid pickle. Mr. Nishimura asked where the mine rope test site was and asked what size and type of rope was used. Dr. Nunninghoff replied that the mine ropes are being tested at Bergwerk Westerholt. Dr. Nunninghoff also noted that each wire in the rope was 2.5 mm in diameter and there was normally 36 wires per rope. He also noted that his results were published in the German publication "Wire."

Hoesch Stahl Report:

Dr. Wolfgang Schwarz presented the results of Hoesch Stahl's latest research on GALFAN sheet, a copy of which is reproduced in the appendix of the minutes. His report illustrates the superiority of GALFAN in certain alkaline ($pH \geq 7.0$) environments.

GALFAN Paintability Report

Mr. Roman presented a compilation of test results relating to the paintability of GALFAN. The rough draft text of that report is reproduced in the minutes, (the photographs are not).

Mr. Roman noted that the previous paintability reports were based on work performed by Parker, Heat Bath, Allied Kelite, DuPont, Amchem, Magne, Inmont, Desoto, Midland, Valspar, Glidden, Hanna, and Lilly. With the exception of DuPont and PPG, most of the work on GALFAN paintability has been discontinued. The results of DuPont work are included in the paintability report. PPG has not responded to a request for additional data.

The main point of the report is to issue a technical report which will be useable for marketing purposes. Mr. Roman's point was that the report was ready for issue and he was looking for constructive criticism or additions to the report. The report was only issued to meeting attendees so that the rough draft could be finalized within a short period of time after the licensee meeting. This report should be available at the same time that these minutes are available.

Mr. Roman emphasized that a great deal of work on paintability has been previously reported. He did not want to bog-down the report with a great degree of technical references. It was his feeling that pictures would be especially useful for marketing purposes, and it was his intent to use pictures showing the superior performance of prepainted.GALFAN.

Continuation of RESEARCH SESSION

June 6, 1990 Session

ATTENDANCE:

Name	Company
Baker, A.	New Zealand Steel
Bontemps, R.	Cockerill-Sambre - Belgium
Bourgeois, P.	Galvameuse (France)
Brinsky, J.	Weirton Steel Corporation
Brugarolas, J.	Procoat SA
Colle, J.	Cockerill Sambre/Branche PHENIX
D'Autilia, A.	ICMI - Italy
Dewitte, M.	Bekaert Belgium
Dubois, M.	Cockerill Sambre/Branche PHENIX
Ehlers, K.	Stahlwerke Peine-Salzgitter
Faderl, J.	Voest-Alpine Stahl Linz
Fukushima, Y.	NKK, Japan
Goodwin, F.	ILZRO
Haines, C.	Pasminco Europe - U.K.
Hennechart, J.	SOLLAC
Hirose, Y.	Nisshin Steel
Hogan, J.	Brailsford Wire Supply Ltd.
Hook, G.	New Zealand Steel
Hosoya, G.	Yodogawa Steel
Hostetler, J.	John Hostetler PE, Inc.
Hudok, D.	Weirton Steel Corporation
Jenkins, A.	British Steel - U.K.
Kinnunen, J.	Rautaruukki Oy
Klotzki, H.	Thyssen Stahl
Kubiak, B.	Metaleurop (France)
Lamberigts, M.	CRM
Leroy, V.	CRM
Lynch, R.	Lynch & Associates, Inc.
Mathieu, S.	SOLLAC France
Matthews, A.	British Steel - U.K.
Mossgrove, D.	Weirton Steel Corporation
Moulin, J.	ARBED
Nishimura, G.	Noranda Sales
Nunninghoff, R.	University Wuppertal/ARBED
Oishi, H.	Sumitomo Metals
Ottersbach, W.	Mannesmann Demag
Parrish, D.	Wheeling-Pittsburgh Steel Corporation
Payne, D.	Bridon Ropes, U.K.
Pierre, M.	Centre du Zinc
Rodellas, F.	Procoat SA
Roman, M.	ILZRO

Attendance (contd.)
Research Session , June 6, 1990

Name	Company
Romu, K.	Rautaruukki Oy
Sambuco, E.	Wheeling-Pittsburgh Steel Corporation
Sempels, R.	Vieille-Montagne
Schwarz, W.	Hoesch Stahl AG
Szydlik, A.	Stahlwerke Peine-Salzgitter
Tsuji, K.	Kobe Steel Ltd.

Status Update on North American Weldability Trials:

Mr. Roman, in finishing the research session, presented a summary of the work being carried on in North America to promote the weldability of GALFAN. Since the agenda had been made up in late March, Mr. Roman expected to have an April meeting of his weldability group, but that meeting had since been postponed to June 21 (and then to July 12). Therefore, there was no new work to report on, only a brief review of the project was available.

Mr. Roman noted that the automotive market in North America has a tremendous potential for GALFAN usage, however it has been restricted for two reasons. One reason is that only one supplier of GALFAN is available, that is, Weirton Steel. With the addition of Wheeling-Pittsburgh Steel in the near future that problem will be eased. Also, a major reason for the lack of automotive usage of GALFAN is the lack of confidence in the automotive industry in the weldability of GALFAN. Mr. Roman noted that ILZRO, The Edison Welding Institute, and Massachusetts Institute of Technology had shown that there was a positive trend for improving the weldability of GALFAN by using the upsloping technique in the welding of GALFAN. Briefly, the upsloping technique introduces a gradual increase in weld current from zero to full power in the welding schedule for GALFAN, allowing the electrode tip to push through the softened GALFAN rather than splattering it and causing alloying with the copper during the "normal" instant full power-on weld schedule. This upsloping technique has been well-documented and was previously reported in the May 1987 Pittsburgh USA licensee meeting minutes.

Weirton Steel of USA confirmed the ILZRO-EWI-MIT welding work, highlighting the improved weldability of GALFAN at the May 1987 Pittsburgh USA meeting, however there has been a distinct lack of confidence in those weld results shown by the automotive industry as well as other GALFAN licensees. Therefore, in the spring of 1989, Mr. Roman organized a task force whose purpose was to prove or disprove the claims for improved weldability of GALFAN via the upslope method. Initially most major steel producers were invited to participate. Those producers were: USX Corporation, Bethlehem Steel, Weirton Steel, Wheeling-Pittsburgh Steel, National Steel, Armco Steel, Inland Steel, and LTV Steel. The companies that responded positively were Weirton Steel, Wheeling-Pittsburgh Steel, LTV Steel, Inland Steel and Armco Steel. Note that only Weirton Steel, Inland Steel, and Wheeling-Pittsburgh Steel are GALFAN licensees (it is hoped that once the weldability of GALFAN is proved or confirmed that the current GALFAN licensees such as Inland Steel would consider the production of GALFAN, whereas the non-licensees such as LTV Steel or Armco Steel may be convinced to acquire a GALFAN license and begin GALFAN production).

The initial thrust of the project was to prove to the steel companies themselves that the upsloping method did work. Weirton Steel offered guidance and samples so that LTV, Inland, and Armco (Wheeling-Pittsburgh is an observer since they will soon become a second source/supplier in North America). In the meetings of June 1989, October 1989, and March 1990, that first task was completed. A positive trend by the use of upsloping has shown that only GALFAN benefits from the use of upsloping, that is, the weldability of GALFAN was significantly improved by using upsloping. The weldability of galvanized steel did not show an improving trend. This is possibly why other steel companies have been skeptical of the initial Weirton Steel results because it is possible they only tested upsloping on galvanized steel.

The next goal of this task force is to fine tune the direction of this work in order to best produce improvements in weldability for GALFAN.

The overall long-term of this task force is to prove to the North American automotive industry that GALFAN can be welded and is usable therefore hoping to stimulate the consumption of GALFAN sheet in the North American auto industry.

Mr. J.P. Hennechart of SOLLAC asked Mr. Roman if he thought that the issue of dissimilar metals within an automotive body could be a problem. Mr. Roman noted that although he feels that there may be some problems, he felt that they would be small compared to the huge obstacle of overcoming the preconceived poor weldability of GALFAN. Mr. Roman noted that once GALFAN can be proven to be weldable to the automotive industry he felt that the subject of dissimilar metals would be a problem that can be dealt with.

MARKETING SESSION

Dr. Richard Lynch, of Lynch & Associates USA, chaired the session. He restated the new goals for the formation of GALFAN International, Inc. He then moved on ahead immediately to the agenda and introduced Mr. Roman.

New GALFAN Licensees:

Mr. Roman noted that, as he said the previous day, there were two new GALFAN licensees since the Helsinki (July 1989) meeting. They were Caledon Tubing of Mississauga, Ontario, Canada, and ITT-Higbie Automotive Group of Auburn Hills, Michigan, USA. Mr. Roman then reviewed the unique situation of GALFAN tubing in North America. An article written for American Metal Market covers that subject thoroughly and is reproduced in the minutes of the meeting.

One question raised by Mr. David Parrish of Wheeling-Pittsburgh Steel related to the alloy licensee situation in North America. He asked if there were any other sources of GALFAN alloy in America, since there are tariff restrictions between the U.S. and Canada. Dr. Goodwin interjected noting that the Big River Minerals Corporation was now a new ILZRO member and will be a GALFAN alloy licensee. This alloy license is actually the assignment of the old AMAX GALFAN alloy license.

GALFAN Patent Estate:

Mr. Roman covered the subject of new patents granted to ILZRO for GALFAN. The total patent estate is reproduced in the minutes. The new patents were for Czechoslovakia #261856, 27 January 1989, Italy #1,210,618, 14 September 1989, and Japan #1541930, 31 January 1990. Mr. Roman noted that the Italian and Japanese patents were very important because there are GALFAN licensees in both of those countries wherein also GALFAN sales in both of those countries.

Dr. Hirose asked if ILZRO had heard of any objections to the GALFAN patent in Japan. Mr. Roman replied that he knew of no objections to the patent and it was apparently issued as written, but he would double check this upon his return to the U.S.A.

GALFAN Tonnage:

Mr. Roman reviewed the 1989 actual tonnage and 1990 forecasted tonnage for GALFAN. The alphabetical (by company) results are listed in the appendix. The actual total for 1989 is approximately 228,000 tons. The forecast for 1990 is approximately 287,000 tons, a 26% increase. The numbers listed herein include unavailable figures at the time of the Liege meeting but confirmed after the meeting by Mr. Roman.

Some highlights of this discussion were: Inland Steel's (USA) actual 1990 production was approximately 2 tons, all produced on their laboratory pilot line. ITT-Higbie Automotive (USA) will begin start-up trials in July 1990; Caledon Tubing should start-up later in 1990. Anticipated 1991 start-ups for GALFAN will be conducted at: New Zealand Steel, Nippon Denro Ispat (India), Thyssen Stahl (West Germany) (or late 1990), Voest Alpine Stahl (Austria), and Wheeling-Pittsburgh Steel (USA). Please note that the lower tonnage figure for Weirton Steel is due to line outages due to plant modernization.

Dr. Lynch then introduced the individual licensee reports for each market.

British Steel Report:

Mr. Austin Matthews reported on GALFAN at British Steel. He noted that there has been no GALFAN production at British Steel. He noted that 1989 was a slow year for galvanized products at BSC, but he felt that GALFAN looks to be an excellent substrate for their prepainted market. He emphasized that GALFAN would be a big change for BSC to implement and therefore GALFAN is still on the drawing board for BSC. Mr. Matthews noted that there are no intentions (in hard terms) to produce GALFAN at BSC but as everyone present knows anything could change in 1991.

Speaking for the Zinc Development Association (ZDA-London) he noted that there has been a limited response on GALFAN as well as a limited campaign for GALFAN. Both ZDA and British Steel will coordinate with the European Zinc Institute (EZI) and in the near future as things develop they also should coordinate with GALFAN International, Inc.

Mr. Matthews noted that one big potential market that he sees for GALFAN would be the use of preprimed GALFAN for the automotive after-market, that is, for body shop panels. This market requires an extremely good surface and would be more critical than weldability because these parts are likely to be bolted onto a car. Mr. Matthews noted that if a good automotive surface can be produced, such a market has great potential.

Mr. Dubois of Cockerill Sambre Phenix Works asked if British Steel had any plans for GALFAN for electrical appliances. Mr. Matthews noted that such a market would require prepainted (powder) painted GALFAN but right now the appliance market in the U.K. is down. Dr. Lynch interjected by noting that all producers are looking at lowering costs and the use of powder post paints is being considered. Dr. Hirose noted that he felt that GALFAN would be difficult to use for exposed automotive panels due to the cosmetic requirement. Mr. Matthews agreed with that statement and again reaffirmed the need to improve the surface quality of GALFAN for exposed body panels. They thought now they could be used for less critical parts and underbody parts.

Bridon Ropes Report:

Mr. Derek Payne made a report on behalf of Bridon (British) Ropes. Mr. Payne noted that 40% of the product generated by Bridon Ropes is galvanized. At present, he sees no GALFAN production for 1990 as well as the first half of 1991. He also noted that if the need arises, GALFAN could be quickly fitted if necessary.

Bridon Ropes is actively promoting GALFAN and is actually buying GALFAN wire from Bekaert, ARBED, and TrefilUNION and selling finished rope and cable.

Mr. Payne noted that GALFAN is not widely known and the name and properties of GALFAN need to be more actively promoted. GALFAN is only really known for structural product usage (e.g. mast stay guy wires, oil rig ropes, fishing rope/cables, etc.).

Mr. Payne noted that within five years British Ropes will have a GALFAN wire line to produce a final undrawn product for the structural market.

Dr. Lynch asked if Dr. Nunninghoff had anything to say about those comments. Dr. Nunninghoff noted that as he had said the previous day, there is a growing market for GALFAN but there is still a tremendous need to promote the product. Dr. Dewitte also added that although there is a big technical push for GALFAN he has not yet seen the marketing pull for GALFAN. Also, based on his own experience at Bekaert, Dr. Dewitte noted that there are many customers of Bekaert were scared off by the Galvalume wire "disaster" therefore potential GALFAN wire customers are being overly cautious about using another zinc aluminum alloy wire. Dr. Lynch interjected noting that he just wanted to make sure that all parties concerned know that Galvalume is an excellent sheet product although its use for wire has not bee positively proven.

Kawasaki Steel Techno-Wire Report:

Mr. Roman commented on a fax received from Kawasaki noting their tonnage and markets. According to Mr. Akio Monna, Superintendent of Chiba Works, their GALFAN wire "... is adopted for use by NTT (Nippon Telephone & Telegraph) for use in overhead and communications cables which require high corrosion resistance." Their other markets are outlined in the appendix attachment.

Indiana Steel and Wire Report:

Dr. Lynch spoke for Mr. Phil Elser of Indiana Steel & Wire. He noted that Mr. Elser and Indiana Steel & Wire are now promoting GALFAN in the U.S. There should be 500 tons of GALFAN wire produced in 1990 and such tonnage should increase significantly in the following years. Dr. Lynch noted that IS&W's market should be that of agricultural fencing or general fencing, and automotive wire. Dr. Lynch also noted that in many cases IS&W's market is growing because they are a second supplier in the U.S. and Canada based on European imports.

Hoesch Stahl Report:

Dr. Schwarz of Hoesch Stahl briefly presented a report on Hoesch's production. He noted that Hoesch Stahl is currently producing approximately 7,000 tons per month of GALFAN and would expect a total production of 80,000 tons of GALFAN in 1990. As of today, the cumulative production of GALFAN at Hoesch Stahl is 160,000 tons.

Dr. Schwarz noted that the Hoesch Stahl markets for GALFAN were the following:

Construction	55%
Appliance	20%
Automotive Accessories	15%
Miscellaneous	10%

He noted that most of the construction tonnage is for Hoesch's own construction subsidiary.

Dr. Schwarz noted that Hoesch Stahl asks for and gets a 30 DM per ton premium for GALFAN over galvanized. Mr. J.M. Colle of Cockerill Sambre asked Dr. Schwarz to provide more detail on their construction markets. Dr. Schwarz noted that the construction market for Hoesch Stahl is profiles for roofing, siding, window frame, sandwich panels, etc.

Stahlwerke Peine-Salzgitter Report:

Mr. Szydlik noted that production of GALFAN at Salzgitter was currently small. They do expect it to grow though and he has one big market now - that of the stakes for vineyard applications which require powder painting.

Thyssen Stahl Report:

Dr. Klotzki noted that there are customers of Thyssen who want to switch to GALFAN, especially in the automotive accessory market. This application would require the excellent formability of GALFAN. Thyssen Stahl currently has testing underway. Dr. Klotzki noted that if there were a bigger supply of GALFAN, there would be bigger markets for it.

Rautaruukki Oy Report:

Mr. J. Kinnunen of Rautaruukki noted that 90% of GALFAN is coil coated for the construction and appliance market, however, for the time being due to surface quality problems, the production of GALFAN at Rautaruukki has decreased.

Note thorough coverage of this subject in the 1989 Helsinki minutes.

SOLLAC Report:

Mr. J.P. Hennechart reported on behalf of SOLLAC. His report is reproduced in the minutes appendix. Briefly, the highlights of the report are. SOLLAC produced 7,000 tons in 1989, will produce 14,000 tons in 1990 and expects to go to 20,000 ton per year figure by 1991.

Dr. Schwarz asked if SOLLAC produced any very light coatings. Mr. Hennechart replied that SOLLAC does not do so, but it is a good idea. Mr. Matthews asked if Zinquench was used only for GALFAN. Mr. Hennechart noted that GALFAN is only usually produced with Zinquench but is available for galvanized product. It is used to control the surface quality and the bath temperature. Mr. Matthews noted that he recalls that Rautaruukki is using Zinquench for GALFAN. Mr. Kinnunen of Rautaruukki interjected noting that Rautaruukki does use Zinquench for GALFAN but the domestic Finnish markets are limited and they are looking for export potential. Mr. Matthews then asked if the Zinquench system is the same at Rautaruukki and SOLLAC. Dr. Lynch interjected noting that it is a RASMET licensed product in that the two lines are similar with inherent differences due to line differences. Mr. Kinnunen of Rautaruukki now noted that not only can they produce dual phase steels with Zinquench but also control the bath temperature and clean the pot very efficiently.

ICMI Report:

Dr. A. D'Autilia of Industrie Cantieri Metallurgici Italiani (ICMI) noted that ICMI produces GALFAN in limited campaigns for the bare and prepainted electrical components and appliance markets. Dr. D'Autilia noted that ICMI is carefully investigating the potential for very light coating weight GALFAN (70 g/m^2 two side total).

Mr. Roman pointed out that Dr. D'Autilia presented the paper "GALFAN: A World Overview," authored by himself and Dr. Lynch at the United Nations Conference "Steel '90" held in Genoa in May 1990. Mr. Roman thanked Dr. D'Autilia for his efforts. Dr. D'Autilia summarized very quickly that there were many representatives for Galvalume and other alloy coatings at the conference and that GALFAN had a good response, but questions were limited by session chairmen due to the length of many presentations. Mr. Roman also added he felt it was important that such a paper be presented to such an audience which he expected would consist of many representatives from eastern bloc countries now that political relations are easing. No technical secrets were given away in this paper. It was a very general publication of facts that are well-known to GALFAN licensees but would act as a good introduction to someone not that familiar with GALFAN.

European Zinc Institute Report:

Mr. Ray Sempels of Vieille-Montagne Belgium reported on behalf of the European Zinc Institute. Mr. Sempels noted that as before, the European Zinc Institute has presented GALFAN in two steps. The first step is a passive one, establishing the GALFAN name. He said there was a mixed response to that step. The second step was a promotional step. He noted the difficulties in that step were where to make it and within what markets. He also noted other difficulties in the marketplace were: Why only GALFAN (when Galvalume, galvanizing, and electrogalvanize are also available?). What price should GALFAN be and what type of GALFAN should be made available? Mr. Sempels noted that EZI needs more cooperation with the producers as well as coordination with customers. Mr. Sempels ended by noting that the European Zinc Institute is actively promoting the "4 G's" (GALFAN, Galvalume, galvanized, and electrogalvanized).

Mr. Matthews noted that what Mr. Sempels had said is right and absolutely true. He noted that it is possible that the EZI didn't have ready access to all the markets and noting that prepainted GALFAN is a big potential around the world, Mr. Matthews suggested that Mr. Sempels and/or the EZI should coordinate it with the ECCA (European Coil Coating Association) to promote GALFAN as a prepainted substrate.

In introducing Mr. Chris Haines of Pasminco Europe, Dr. Lynch noted the presence of GALFAN Alloy Licensees at the meeting (Vieille-Montagne, Pasminco Europe, Metaleurop, and Noranda).

Pasminco Europe Report:

Mr. Chris Haines briefly noted that he agreed with much of what had been said previously. He noted that Pasminco's concerns with GALFAN are very closely linked to British Steel, but not confined to British Steel.

Noranda Sales Report:

Mr. Glen Nishimura made comments on the GALFAN market in Canada. He noted that Noranda along with Cominco, Falconbridge, and Eastern Alloys (USA) had supported the ILZRO Project ZM-358 which was the market promotion of GALFAN in North America. That project has now ended and he is awaiting the final report, but he is still looking forward and looking at the potential markets for GALFAN. He noted he was glad to see that Wheeling-Pittsburgh was on-track to begin production in 1991 and he also confirmed an earlier remark that there is a need to get a major GALFAN producer in Canada, since there is a 19% tariff between the U.S. and Canada for alloys.

Weirton Steel Report:

Mr. Don Mossgrove reported that Weirton Steel produced 24,000 short tons (19,000 MT) of GALFAN in 1989 and the plans for 1990 were for 20,000 short tons (18,000 MT). The lower figure is due to production outages planned on increasing capacity at Weirton Steel. Such outages have obviously created scheduling and material shortages, but there definitely is not a lack of interest in GALFAN. He noted that Weirton Steel sees a daily interest in GALFAN and welcomed the presence of Wheeling-Pittsburgh as a second supplier who should stimulate the market for GALFAN.

Mr. Mossgrove broke down some of the markets for GALFAN. They are:

- •Automotive-Mostly Underbody and Accessories
- •Construction-Roofing, Siding and Garage Doors
- •Appliances-Washers and Dryers, etc.
- •Electrical-For Lighting and UL Approved Parts

Mr. Mossgrove noted that Weirton Steel is targeting the prepainted roofing and siding market, especially that of the pre-engineered buildings.

Mr. Mossgrove broke down the product mix of GALFAN. Weirton Steel has the capacity to produce GALFAN in the gauge range of .010 inches - .168 inches. He noted most GALFAN was produced at .010 - .0175 inch. Maximum width is 48 inches. He noted that GALFAN is normally produced one week a month at Weirton Steel. Production is alternated between light and heavy gauge per month.

Wheeling-Pittsburgh Report:

Mr. David Parrish noted that Wheeling-Pittsburgh is planning to start GALFAN production in the first quarter of 1991. The obvious difference at Wheeling-Pittsburgh is that GALFAN will be produced on Wheeling Pittsburgh's 48 inch Cook-Nortemann galvanizing line which is capable of .3 to 2.0 mm in gauge. This Cook-Nortemann sheet line will be the first of its kind in the world and is therefore requiring a tremendous amount of first-time ever engineering.

Mr. Parrish noted that a large potential market for GALFAN at Wheeling-Pittsburgh is for the construction market. Wheeling-Pittsburgh Steel owns Wheeling Corrugation and he sees that the market for roofing and siding of corrugated products should have a large potential. At first, most Wheeling-Pittsburgh GALFAN will be roll formed with some attention to the roll formed culvert market. Although the market is not big, Wheeling-Pittsburgh is looking into the automotive market as well as appliances. For appliance and automotive Mr. Parrish noted that they would expect extensive qualification trials.

New Zealand Steel Report:

Mr. Alan Baker noted that New Zealand Steel is looking for a second quarter 1991 GALFAN trial. Most of the GALFAN produced at New Zealand Steel will be for the prepainted markets of which most will be intended for the construction market. About 25% of the GALFAN production at New Zealand Steel would be for the bare applications and Mr. Baker anticipated a problem with the gray patina since their customers must be educated to expect that.

Again Mr. Baker noted that the big anticipated problem at New Zealand Steel for the construction is the production of full hard GALFAN, which will require an extremely clean strip.

Mr. Baker noted that eventually New Zealand Steel wanted to go to a product mix of 75% GALFAN, 25% galvanized.

Nisshin Steel Report:

Dr. Hirose noted that production at Nisshin Steel was now at the 6,000 ton per month figure. In June of 1990, that figure will rise to 6500 tons per month. 2000 tons will be painted, 4500 tons will be bare. He expects that by November and December of 1990 that production figure will rise to 16,000-17,000 tons per month.

Gauge capabilities at Nisshin Steel are 0.2 - 6.0 mm. By the end of the year, one-third of that 16,000-17,000 ton per month figure will be produced in the 0.2-2.3 mm gauge range. One-third will be produced at the 3.2 mm gauge size and the other third will be produced in the 4.5-6.0 mm gauge size. Dr. Hirose confirmed that obviously most of the GALFAN at Nisshin was for heavy gauge material. Dr. Hirose noted that Nisshin Steel has done much work in selling GALFAN in the pre-engineering housing market. The need in this market is long life for the "century house" (100 year life).

Dr. Lynch asked what the coating weights required were for the century house. Dr. Hirose replied that it would be 160 g/m^2 per side. Mr. Matthews asked if the century house was a market entity or was it required by law. Dr. Hirose noted that it was a market requirement.

Sumitomo Metal Industries Report

Mr. Oishi noted that in 1989, 22,000 tons of GALFAN was produced of which 60% was prepainted intended for the construction market. He noted that the prepainted material was in the gauge range of 0.27-1.2 mm. Bare material is produced at 1.4 mm gauge intended for the housing industry.

Yodogawa Steel Report:

Mr. G. Hosoya noted that prepainted material accounts for 80-90% of Yodogawa's GALFAN production. Yodogawa produced 11,670 tons in 1989 and intend to produce 12,500 tons in 1990. Bare product produced at Yodogawa is for the pre-engineering construction market. Most coatings weights at Yodogawa are in the 185-250 g/m^2 two side total. Gauge range for GALFAN at Yodogawa is 0.27 mm - 1.2 mm.

Gary Hook of New Zealand Steel asked Mr. Hosoya if Yodogawa produced any full hard. Mr. Hosoya noted that Yodogawa did produce full hard without any problems. He noted that when full hard was produced, Yodogawa kept the GALFAN bath at 460°C. Dr. Lynch asked if anyone else does full hard GALFAN. Dr. Hirose interjected by noting that there is the previously mentioned problem of surface cleanliness and wettability. Mr. Oishi of SMI noted that full hard GALFAN was produced with the use of a titanium-stabilized IF steel which allowed higher furnace temperatures. Dr. Lynch thanked Mr. Oishi for that comment but noted that discussion of that subject should be saved for the next day's Operators Session. Mr. Hennechart did want to add a comment noting that SOLLAC produces annealed GALFAN and temper rolled at 15-20% elongation to achieve full hard physical properties. Austin Matthews asked of Mr. Hennechart what is the incoming gauge before that temper rolling. Mr. Hennechart replied that it was 0.6 mm. Mr. Schwarz asked what was the steel gauge for the Sumitomo and Yodogawa material. Mr. Oishi replied that it was 0.4-0.5 mm for Sumitomo material and Mr. Hosoya noted that Yodogawa's material is 0.8-1.2 mm.

NKK Report:

Mr. Fukushima noted briefly on behalf of NKK that all the GALFAN that was produced so far is for prepainted material. Gauge range is approximately .35 mm with total coating weight of an average of 270 g/m^2. It was noted that NKK is still in the early stages of GALFAN production, so tonnages have not achieved major status yet but it is still early.

Maruichi Steel Tube Report:

Dr. Lynch noted that there were no Maruichi representatives but noted that Mr. Roman had previously stated that Maruichi intends to produce 3,000 tons of GALFAN in 1990 at Maruichi's new galvanizing line which was just started in November 1989. Dr. Lynch continued by noting that Maruichi plans to use all of their GALFAN as raw material for welded pipe and tubing. Most of the material will be for structural applications of welded pipe. The need for GALFAN arises from requirements for improved corrosion resistance.

Brailsford Wire Supply Report:

Mr. Joe Hogan made a presentation entitled "The Markets of GALFAN (Where Do We Go From Here?)" The entire text of Mr. Hogan's presentation is reproduced in the appendix. One of the main points of Mr. Hogan's presentation is that GALFAN is already well-established in a technical sense as a new product, but still requires marketing and an educational push in order for consumers/end users to accept the still new product.

North America Report:

Dr. Lynch noted that time was running out and he would reduce his presentation from coverage of all GALFAN products in North America to just the new "hot" markets for GALFAN, that being GALFAN tubing. Dr. Lynch mentioned that Mr. Roman had briefly covered that subject in his introduction of the two new GALFAN licensees, Caledon Tubing of Canada, and ITT-Higbie Manufacturing of the USA and referred to the American Metal Market article which is already in the minutes appendix. Dr. Lynch presented an overhead slide on GALFAN tubing (reproduced in the minutes appendix) noting the timeframe in North America for the introduction of GALFAN tubing. Dr. Lynch noted that there is now a strong market pole for GALFAN tubing which may be one of the reasons for some of the new licensees taking on GALFAN. Dr. Goodwin interjected, noting the typical 3 1/2 year time lag from planning to market introduction for specific automotive model year components, etc.

GALFAN International

Dr. Lynch then went on to make some more comments about GALFAN International and plans for the future of GALFAN. The overheads he utilized which outlined the structure and plans for GALFAN International are reproduced in the minutes appendix. Mr. Austin Matthews asked how GALFAN International was to be financed. Dr. Lynch replied that since negotiations were still underway, he could not comment on the exact structure of the financing of GALFAN International other than there are private investors involved.

Standards and Specifications:

Dr. Lynch noted that there is a proposed new standard for "chemical analysis of zinc-5% aluminum-mischmetal alloys by the ICP Argon Plasma Spectrometric Method." (Reproduced in the minutes appendix) by ASTM. Dr. Lynch noted that he would welcome any participation in the final development of this document which covers the chemical analysis of GALFAN. Dr. Lynch also reviewed the current status of standards and specifications in North America. A summary listing of these standards are reproduced in the minutes appendix. Also included is a copy of ASTM A755/A755M-89, the standard specification for "Steel Sheet, Metallic Coated by the Hot-Dip Process and Prepainted by the Coil-Coating Process for Exterior Exposed Building Products."

Dr. Lynch was forced to conclude the meeting, due to lack of time because of the upcoming plant visit to Phenix Works in the afternoon. There has been no decision on the next meeting site for the 1991 GALFAN Licensees Meeting. It is very likely that it will be in May or June of 1991.

European Standards and Specifications:

After the meeting had adjourned, Mr. Joe Hogan supplied a report on European specifications (U.K.). The report is summarized as follows:

Mr. Hogan has noted that the development of standards in the U.K. has been lagging since the invention of GALFAN. Now with the movement towards a unified Europe and i.e. European Community (EC), there is an even greater need for development of GALFAN standards NOW. Mr. Hogan noted that if GALFAN standards and specifications are not immediately acted upon, it is very likely that new European standards may just be an adaptation of old existing standards with new standards put on the back burner for some time. An example of some of the standardizational work in the U.K. is attached in the appendix of these minutes.

Dr. Klotzki of Thyssen Stahl has also supplied information on standards and specifications which are reproduced in the minutes appendix.

PHENIX WORKS TOUR

6 June 1990 (Afternoon)

ATTENDANCE:

Name	Company
Baker, A.	New Zealand Steel
Blondeau, J.	SOLLAC
Brinsky, J.	Weirton Steel Corporation
D'Autilia, A.	ICMI
Ehlers, K.	Stahlwerke Peine-Salzgitter
Faderl, J.	Voest-Alpine Stahl GmbH
Fukushima, Y.	NKK Corporation
Furken, L.	Hoesch Stahl AG
Gailliez, B.	FFM
Goodwin, F.	ILZRO
Guedeu, J.	FFM
Haines, C.	Pasminco Europe
Hennechart, J.	SOLLAC
Hirose, Y.	Nisshin Steel
Hogan, J.	Brailsford Wire Supply
Hook, G.	New Zealand Steel
Hosoya, G.	Yodogawa Steel
Hostetler, J.	John Hostetler PE, Inc.
Hudok, D.	Weirton Steel Corporation
Kinnunen, J.	Rautaruukki Oy
Klotzki, H.	Thyssen Stahl AG
Kubiak, B.	Metaleurop
Lamberigts, M.	CRM
Leroy, V.	CRM
Lynch, R.	Lynch & Associates, Inc.
Mathieu, S.	SOLLAC
Mossgrove, D.	Weirton Steel Corporation
Moulin, J.	ARBED
Nunninghoff, R.	University Wuppertal/ARBED
Oishi, H.	Sumitomo Metals
Ottersbach, W.	MM Demag
Parrish, D.	Wheeling-Pittsburgh Steel
Payne, D.	Bridon Ropes
Pierre, M.	Center du Zinc
Roman, M.	ILZRO
Romu, K.	Rautaruukki Oy
Sambuco, Errol	Wheeling-Pittsburgh Steel
Schoenberger, L.	Voest-Alpine Stahl GmbH
Schwarz, W.	Hoesch Stahl AG
Sugimoto, T.	Nippon Denro
Szydlik, A.	Stahlwerke Peine-Salzgitter
Takeda, K.	Nippon Denro
Tsuji, K.	Kobe Steel

The Phenix Works (Cockerill Sambre/Branche PHENIX) Tour took place the noted date. The tour began with a visit to the Iron and Coal Museum which was about two blocks from the Holiday Inn-Liege. It was a very interesting presentation to see how far the steel industry has come in the last 100 or so years. From there, the group was then bussed to the brand new No. 7 CGL of Phenix Works.

Prior to the actual transportation to the No. 7 line, Mr. Victor Polard, the host for the tour, reviewed some of the specifications and capabilities of the brand new line which had just begun operations a few months earlier.

- Total Cost 2.25 Billion Belgian Francs.
- New line is intended for producing coil coating quality galvanized material. Most applications for the building industry.
- The Exit End of the new No. 7 line is adjacent to the paint line entry facilities.
- The line is capable of 250,000 tons per year production based on 18 shifts per week.
- Gauge range is .25-1.6 mm with 1,650 mm maximum width capability.
- Cleaning section consists of degreasing and electrolytic cleaning before a radiant tube furnace.
- The furnace is a vertical furnace. It was configured that way to produce better shape for higher quality material.
- There is one fixed working bath lined with ceramic bricks with two side or holding pots.
- The air wiping is a design produced by Cockerill Sambre.
- There is no specific cooling device.
- Currently the line uses low lead or zero lead zinc which produces no spangle.
- There is temper rolling in-line as well as tension leveling.
- Maximum entry size of a coil is 30 tons.
- Exit size is 20 tons.
- There is plenty of extra room near the exit end for future unforeseen expansions.
- The exit end has one recoiler.

- Line speed is 180 meters per minute maximum.
- Actual start-up was December 4, 1989.
- So far production has reached 40,000 tons.
- A quality control yield is approximately 80%. Mr. Polard felt that his personnel were still on the learning curve of a start-up operation, but were going to achieve maximization in the near future.

All attendees were allowed to wander around the new facilities freely. The new line is very spacious and impressive. Additional questions were answered after the tour was concluded at the Phenix Works hospitality area.

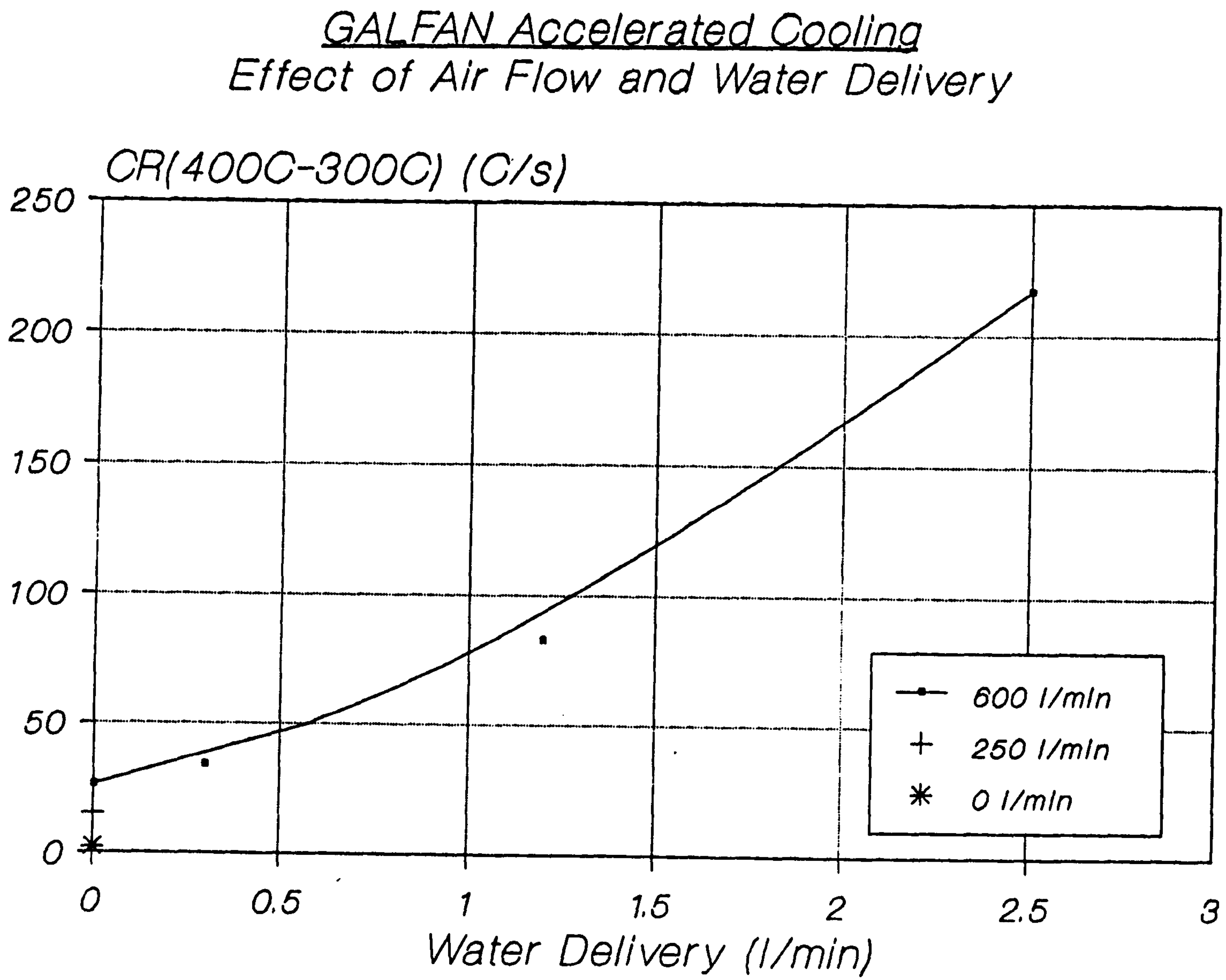
MPR/ja

Attachs.

GALFAN Accelerated Cooling

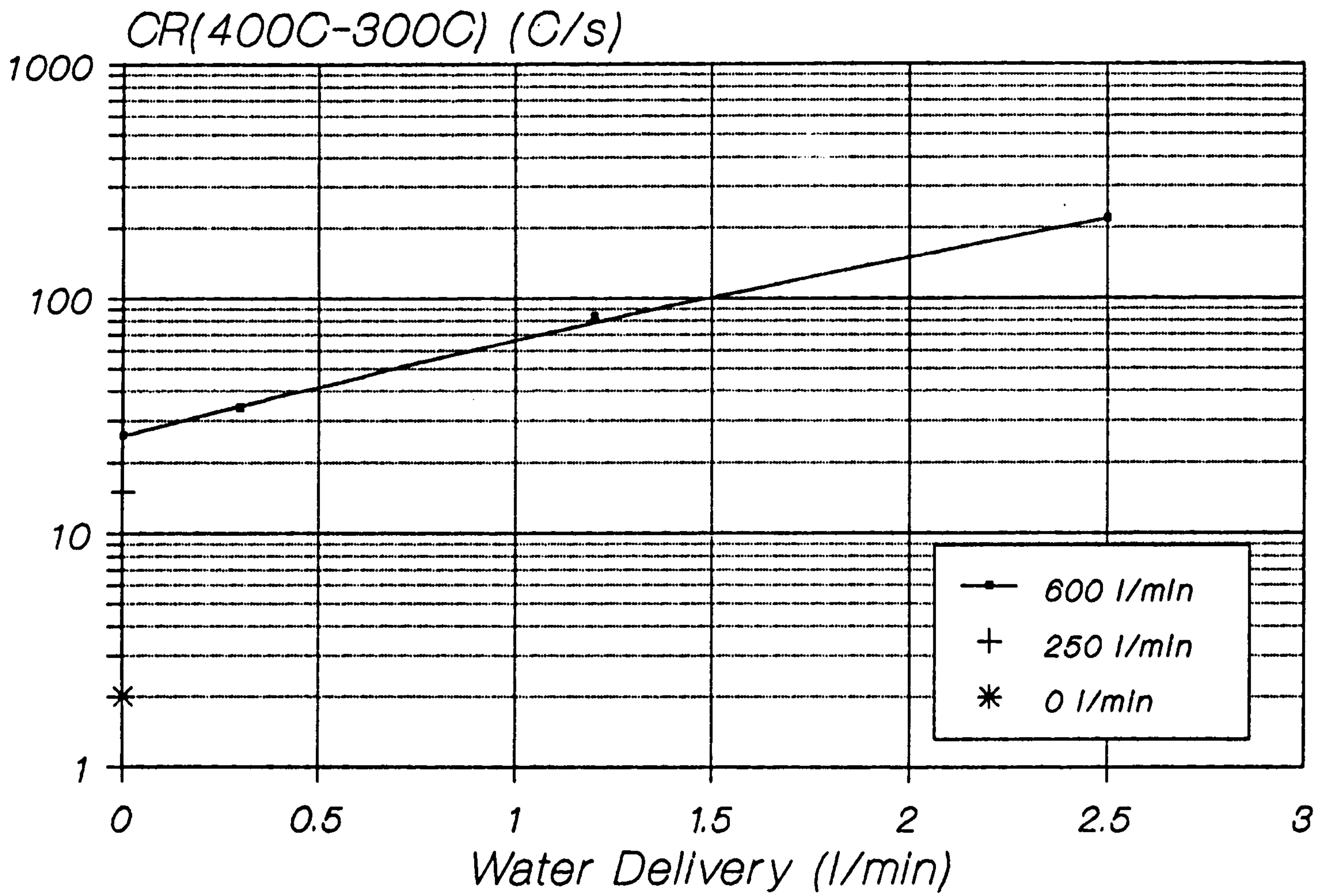
Experimental Conditions

Surface Preparation	Degreasing	Trichloroethylene 1'-RT
	Drying	30"-Hot Air
	Pickling	50% HCl + Inhibit. 1'-RT
	Rinsing	H2O 10"-RT
	Electro-Fluxing	Flor.31G 5"-75 C-4V/10A
GALFANising	Alloy Composition	Zn-4.9%Al
	Bath Temperature	455 C
	Dip Time	10"
	Piston Speed	30m/min
	Air/N2 Wiping	z=80mm th=20mm Velocity=10m/min Pressure=5 bars
Cooling Cond.	Natural	Still Air
	Gas Blowing	Air/Nitrogen 250-600l/min
	Gas-Water Mixt.	Air/Nitrogen: 600l/min+ H2O: 0.3,1.2 and 2.5 l/min

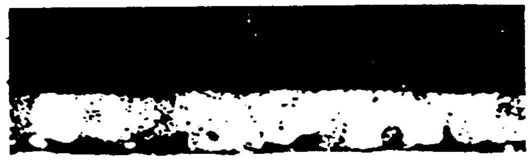
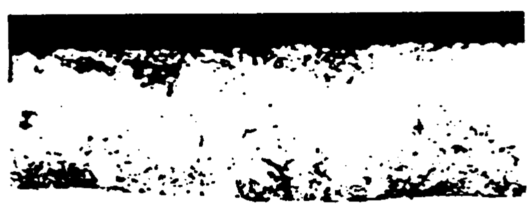
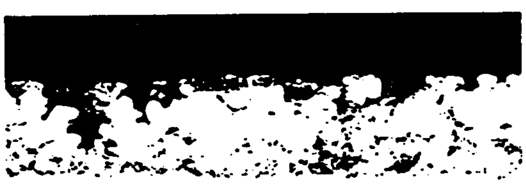
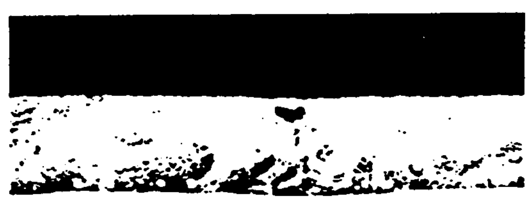
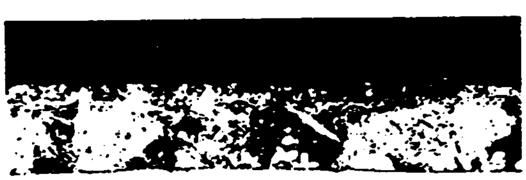

GALFAN Accelerated Cooling
Effect of Air Flow and Water Delivery
CR(400C-300C) (C/s)
250
200
150
100
50
0
0
0.5
1
1.5
2
2.5
3
Water Delivery (l/min)
600 l/min
250 l/min
0 l/min

GALFAN Accelerated Cooling

Effect of Air Flow and Water Delivery



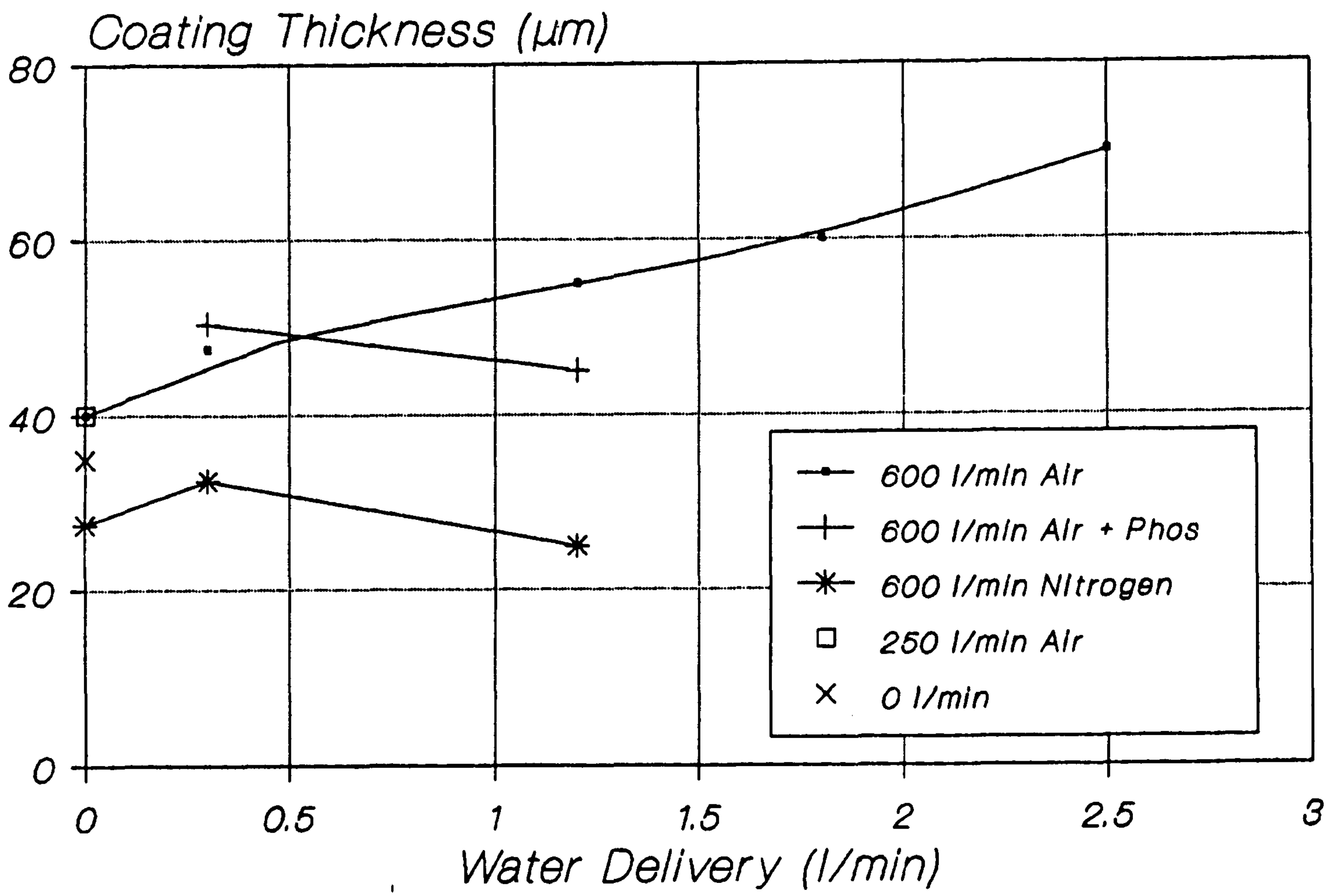
EFFECT OF COOLING RATE ON GALFAN MICROSTRUCTURE

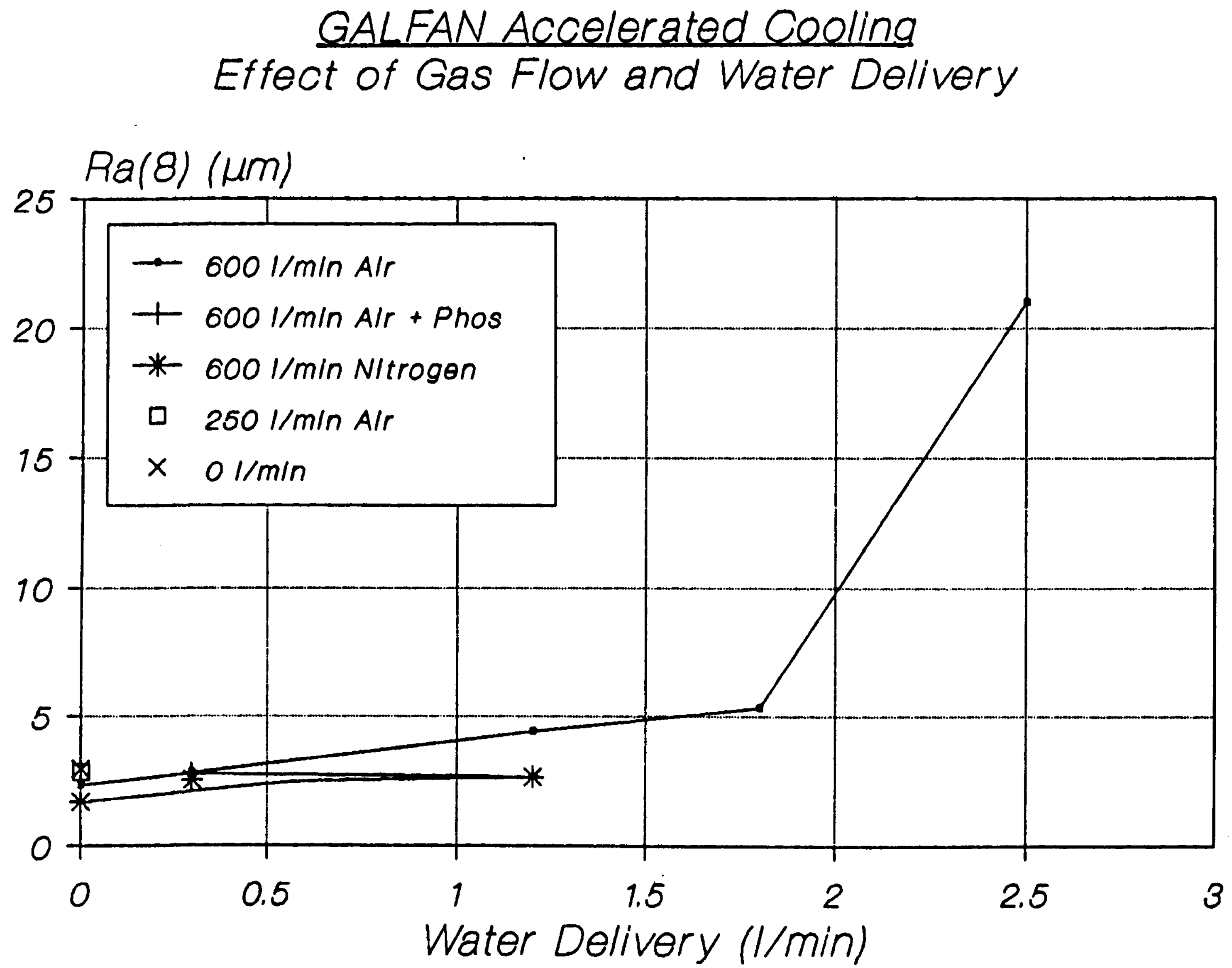
GAS FLOW (l/min)	WATER DEL. (l/min)	C.R. (°C/s.)	AIR	NITROGEN
0	0.0	2		
250	0.0	15		
600	0.0	26		
600	0.3	34		
600	1.2	83		
600	2.5	217		

100 μm

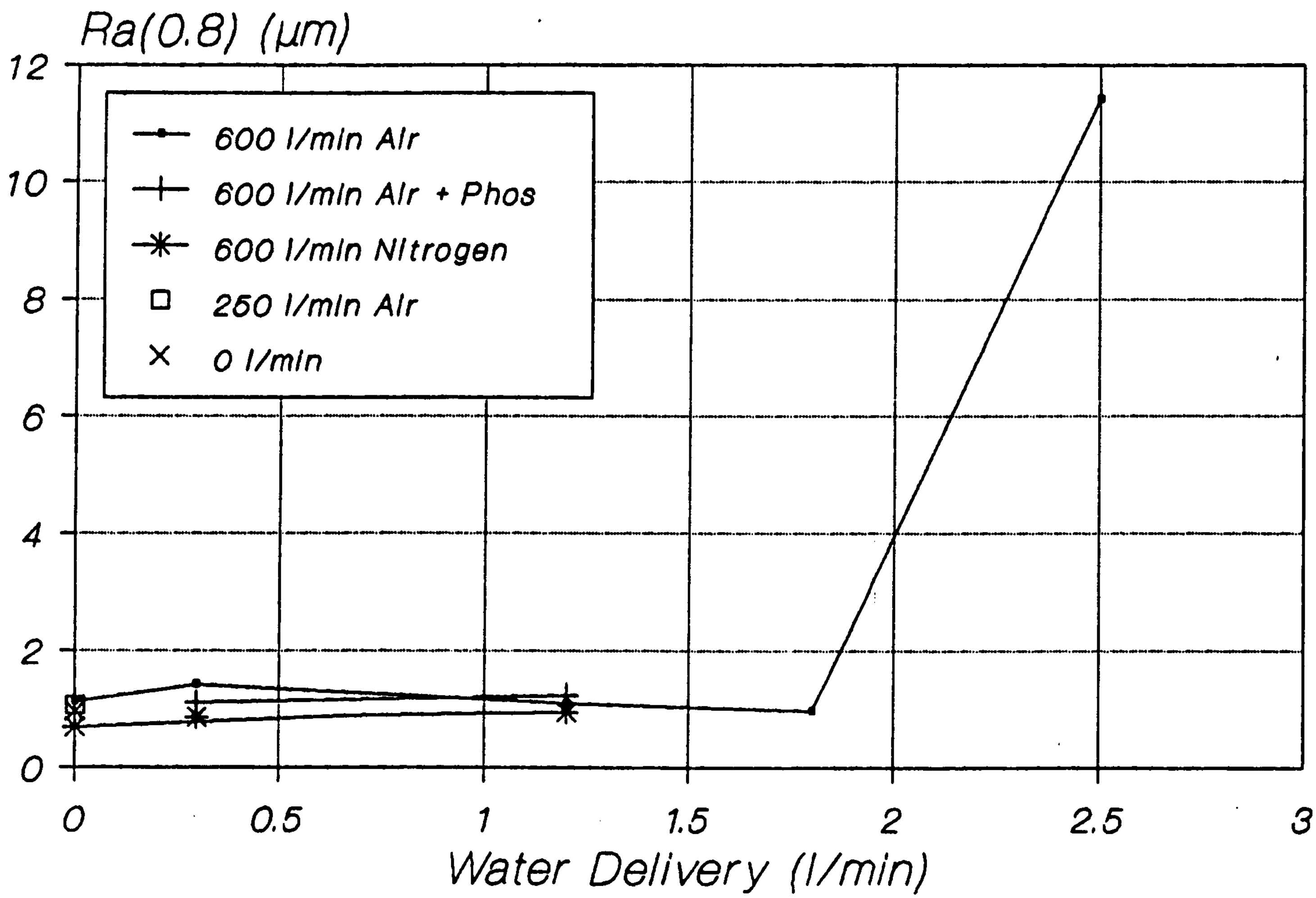
'22199000/23

GALFAN Accelerated Cooling
Effect of Gas Flow and Water Delivery



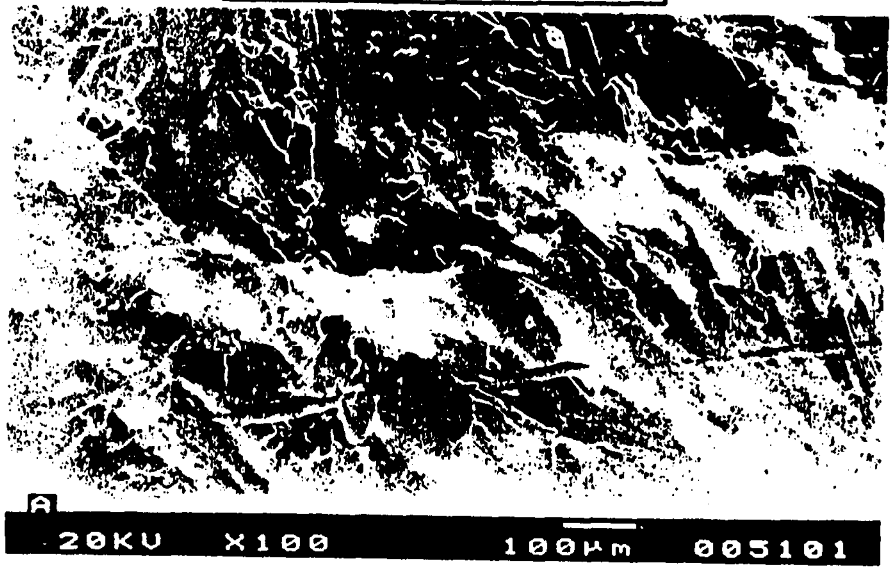

GALFAN Accelerated Cooling
Effect of Gas Flow and Water Delivery
Ra(8) (µm)
25
20
15
10
5
0
600 l/min Air
600 l/min Air + Phos
600 l/min Nitrogen
250 l/min Air
0 l/min
0
0.5
1
1.5
2
2.5
3
Water Delivery (l/min)

GALFAN Accelerated Cooling
Effect of Gas Flow and Water Delivery

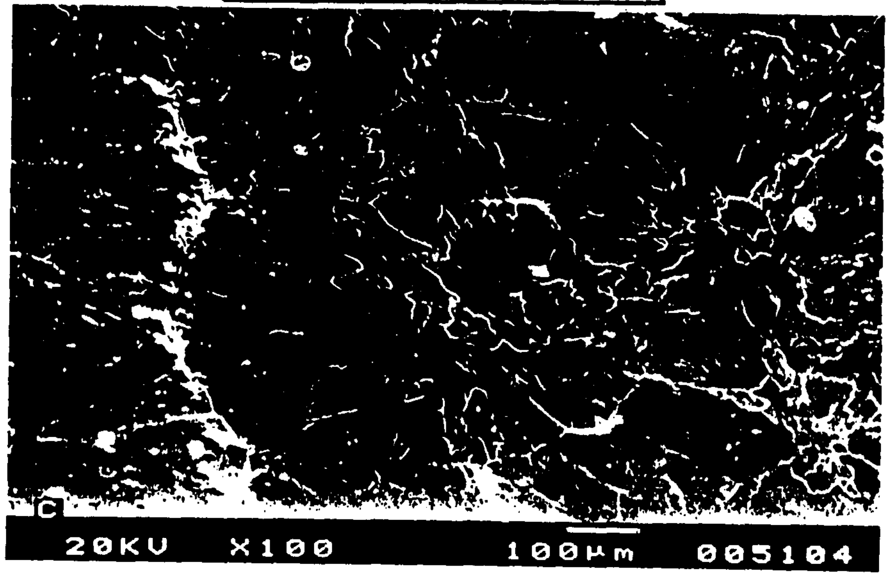


EFFECT OF COOLING RATE ON GALFAN SURFACE CONDITION (AIR)

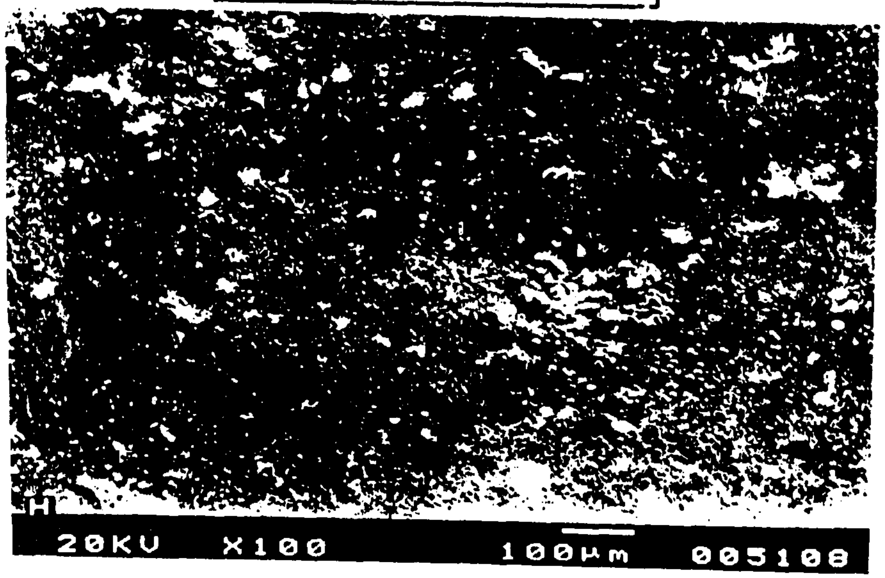
0/0 : 2°C/s



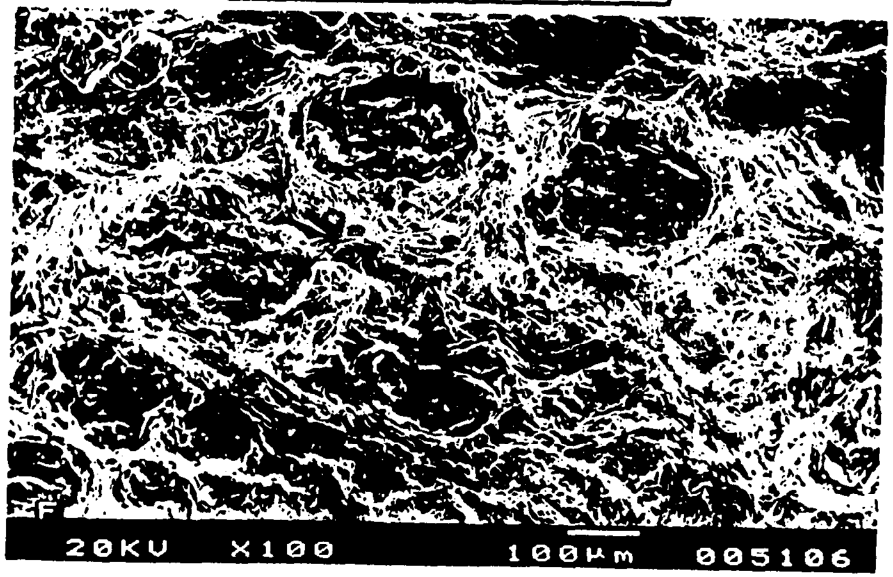
600/0 : 26°C/s



600/1.2 : 83°C/s

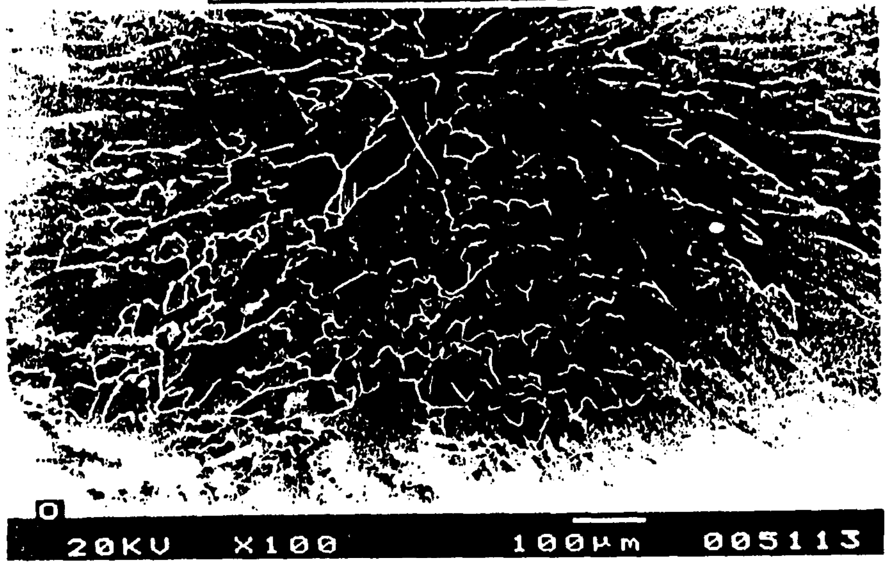


600/2.5 : 217°C/s

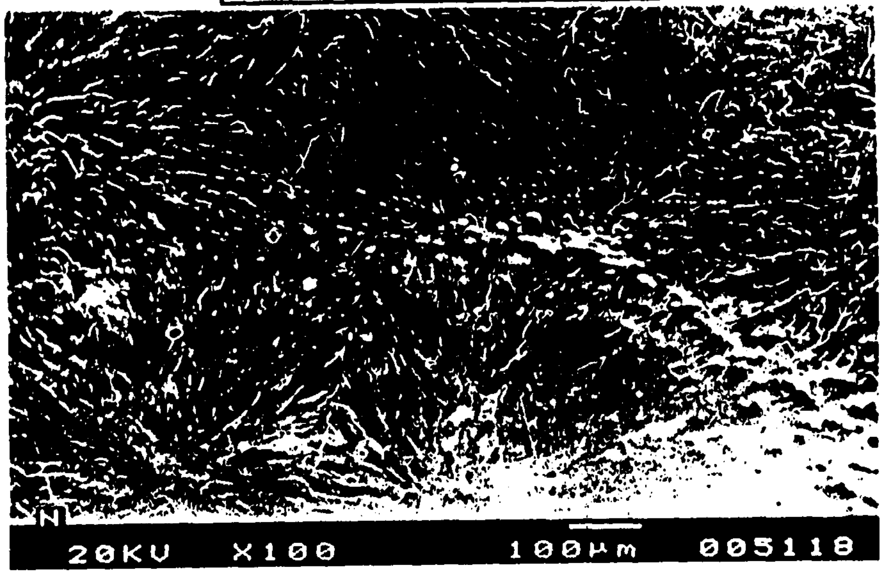


EFFECT OF COOLING RATE ON GALFAN SURFACE CONDITION (NITROGEN)

0/0 : 2°C/s

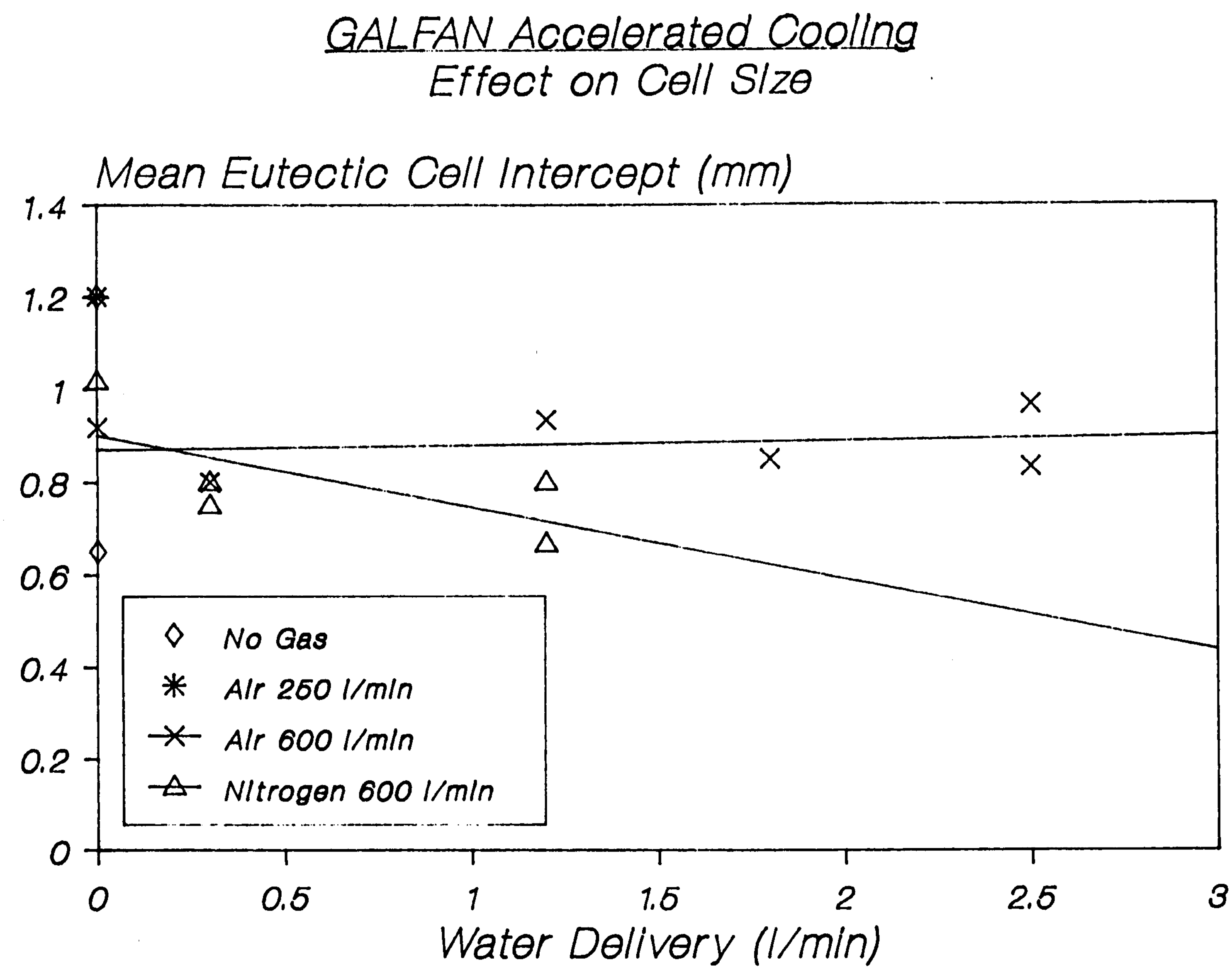


600/0 : 26°C/s

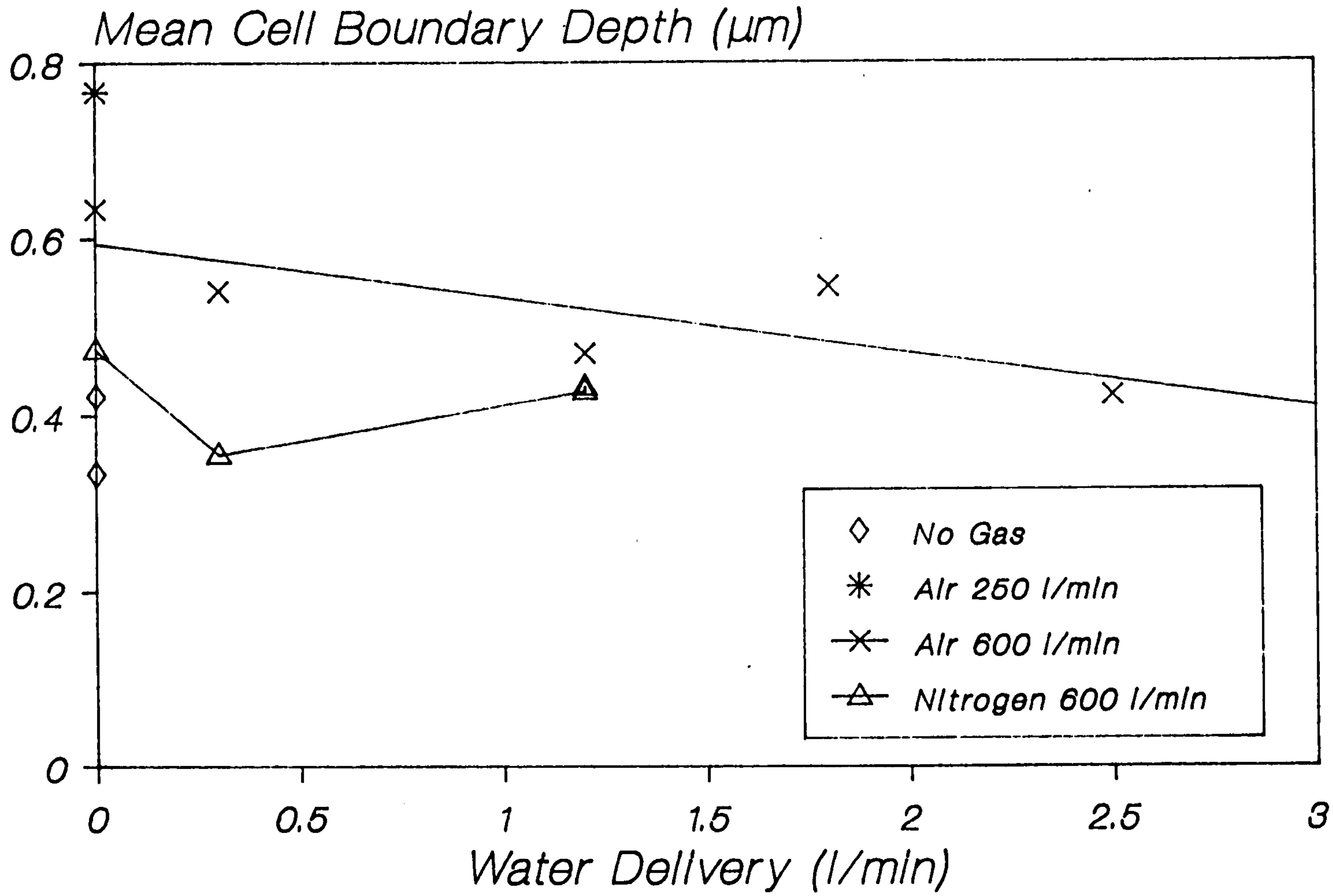


600/0.3 : 34°C/s

600/1.2 : 83°C/s


GALFAN Accelerated Cooling
Effect on Cell Size
Mean Eutectic Cell Intercept (mm)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
0.5
1
1.5
2
2.5
3
Water Delivery (l/min)
No Gas
Air 250 l/min
Air 600 l/min
Nitrogen 600 l/min

GALFAN Accelerated Cooling
Effect on Boundary Depth

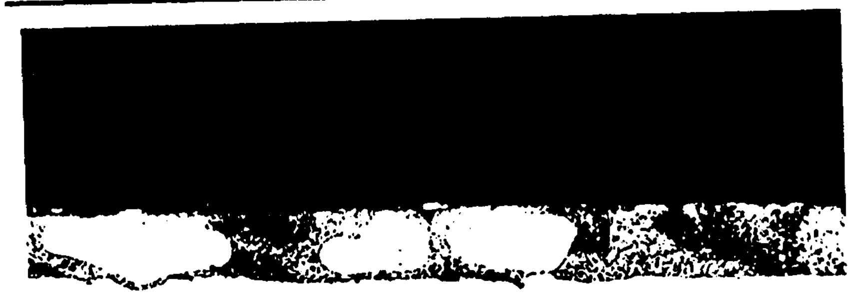


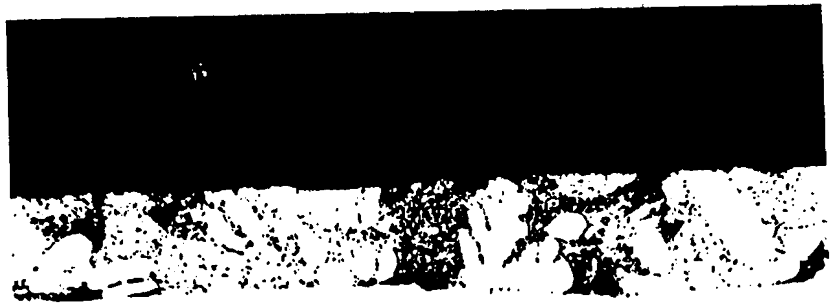
F (600l/min Air+2.5l/min Water) Ignored

EFFECT OF STEEL SUBSTRATE QUALITY ON GALFAN MICROSTRUCTURE

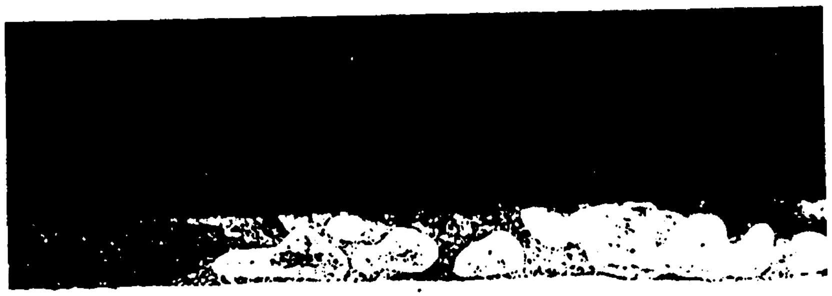
	C	Mn	P	S	Al	Ti	Ni	Cr	Cu	Mo	Si	Sn
)$^{-3}$%	41	283	9	11	54	<1	36	18	37	2	4	9

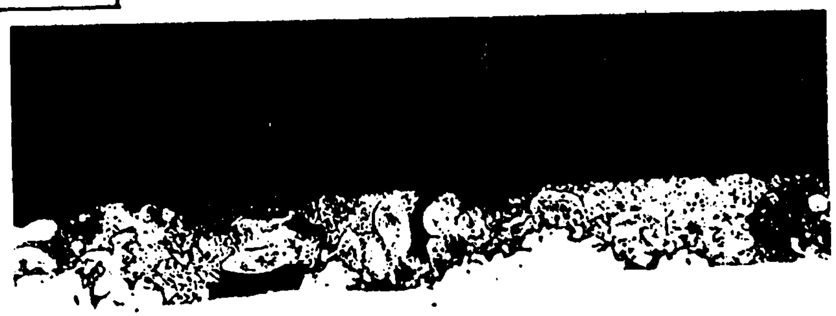
	C	Mn	P	S	Al	Ti	Ni	Cr	Cu	Mo	Si	Sn
10^{-3}%	7	195	8	11	35	118	41	22	39	7	5	4





LONGITUDINAL

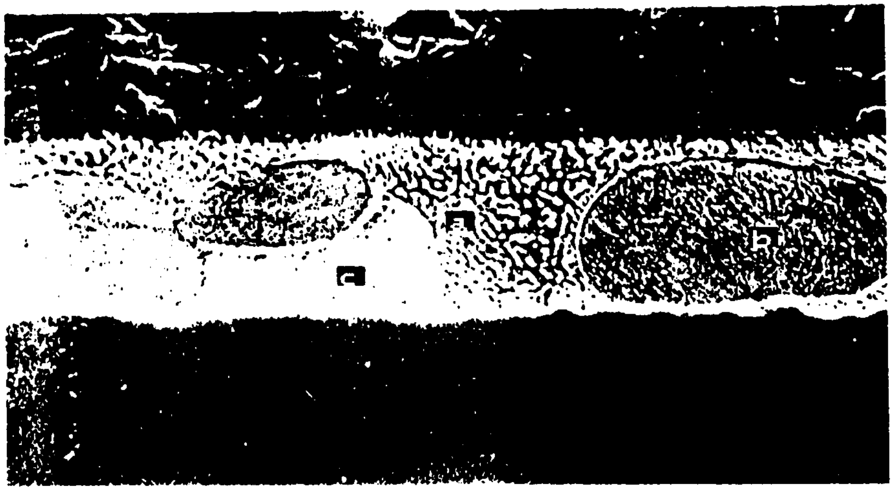


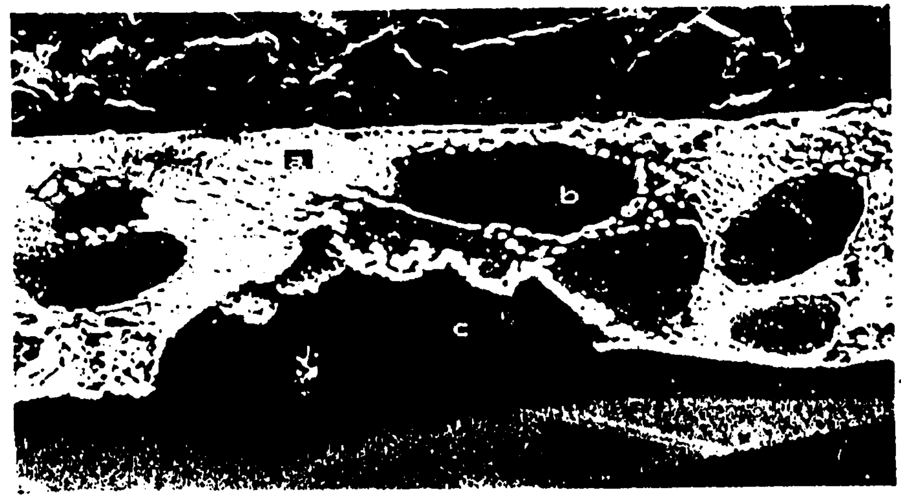


TRANSVERSE

EFFECT OF STEEL SUBSTRATE QUALITY ON GALFAN MICROSTRUCTURE

(41C-283Mn-54Al-36Ni-18Cr-37Cu) | (7C-195Mn-35Al-$\boxed{118Ti}$-41Ni-22Cr-39Cu)





LONGITUDINAL

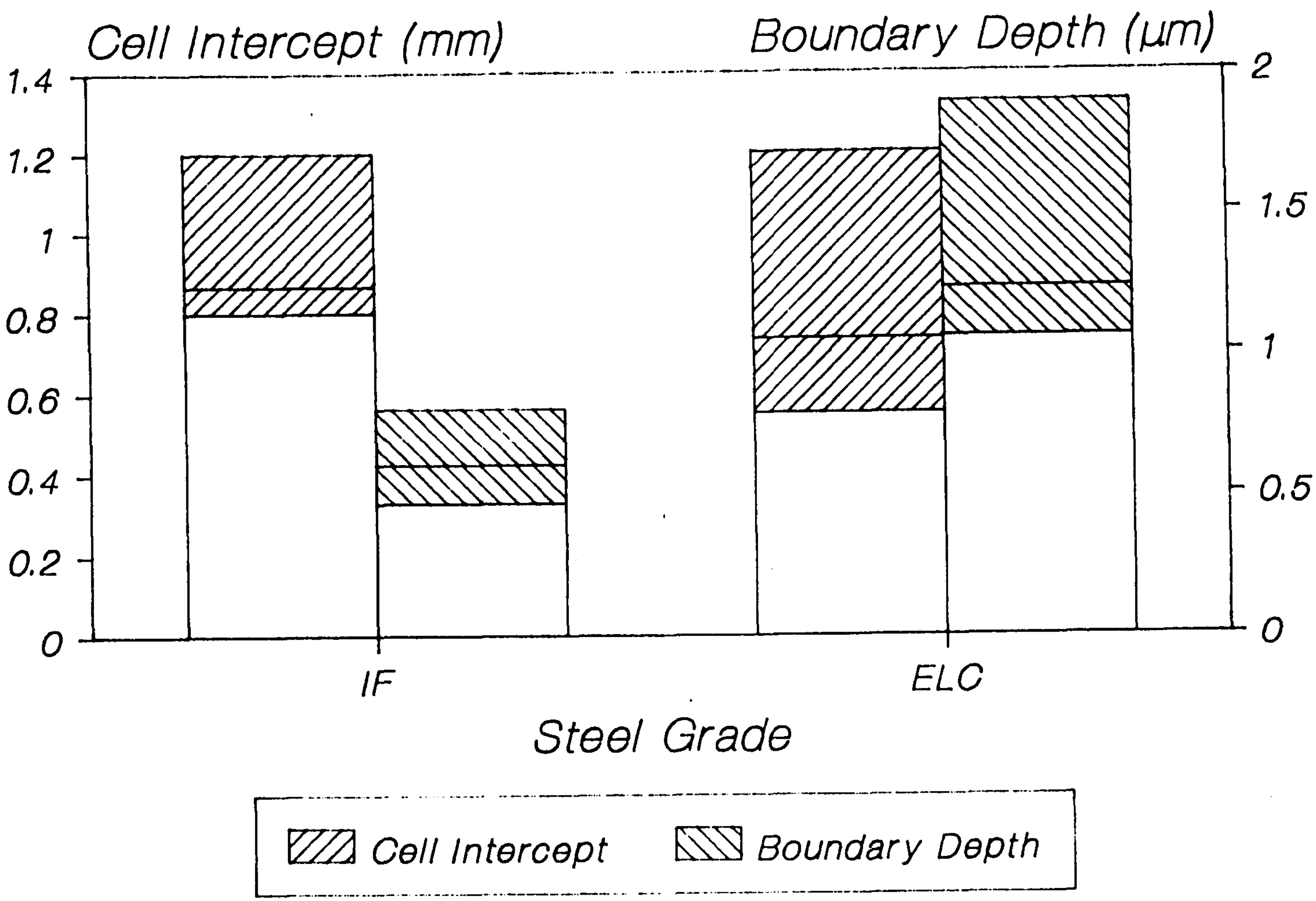
Particles C = (Fe, Zn) Al_x , x = 2 or 3

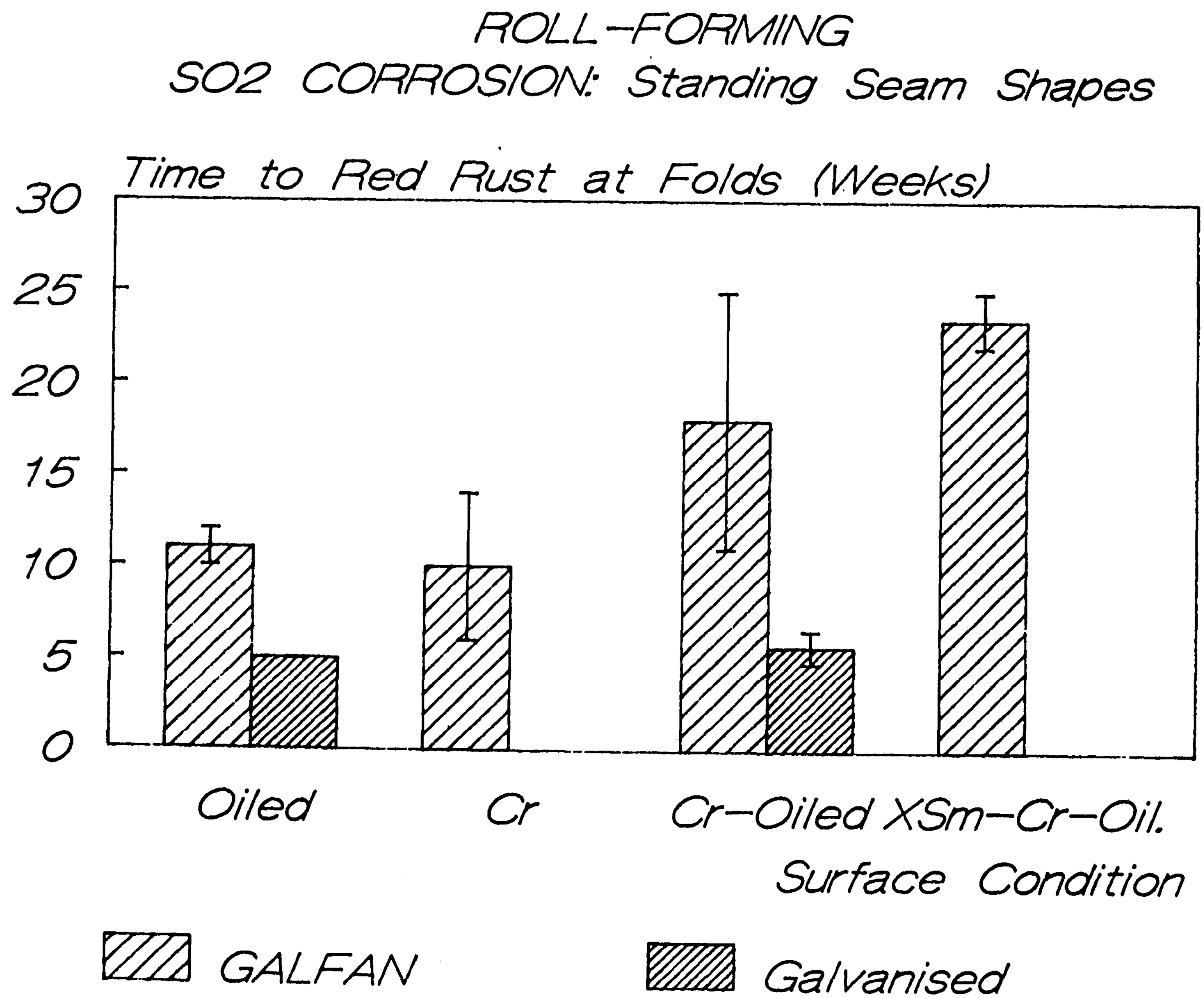
TRANSVERSE

10 μm

19000/25

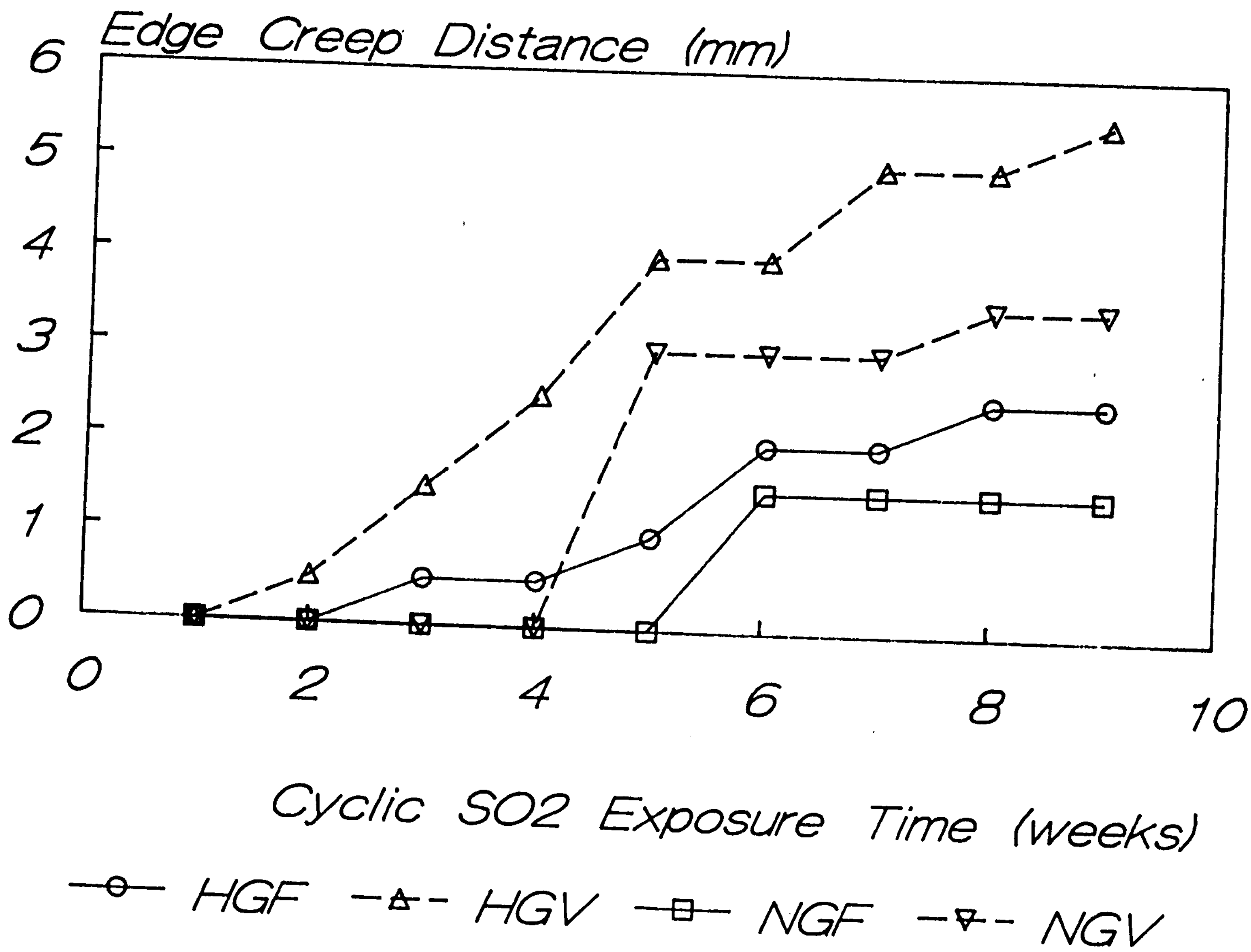
GALFAN Cellular Structure
Effect of Steel Substrate Quality



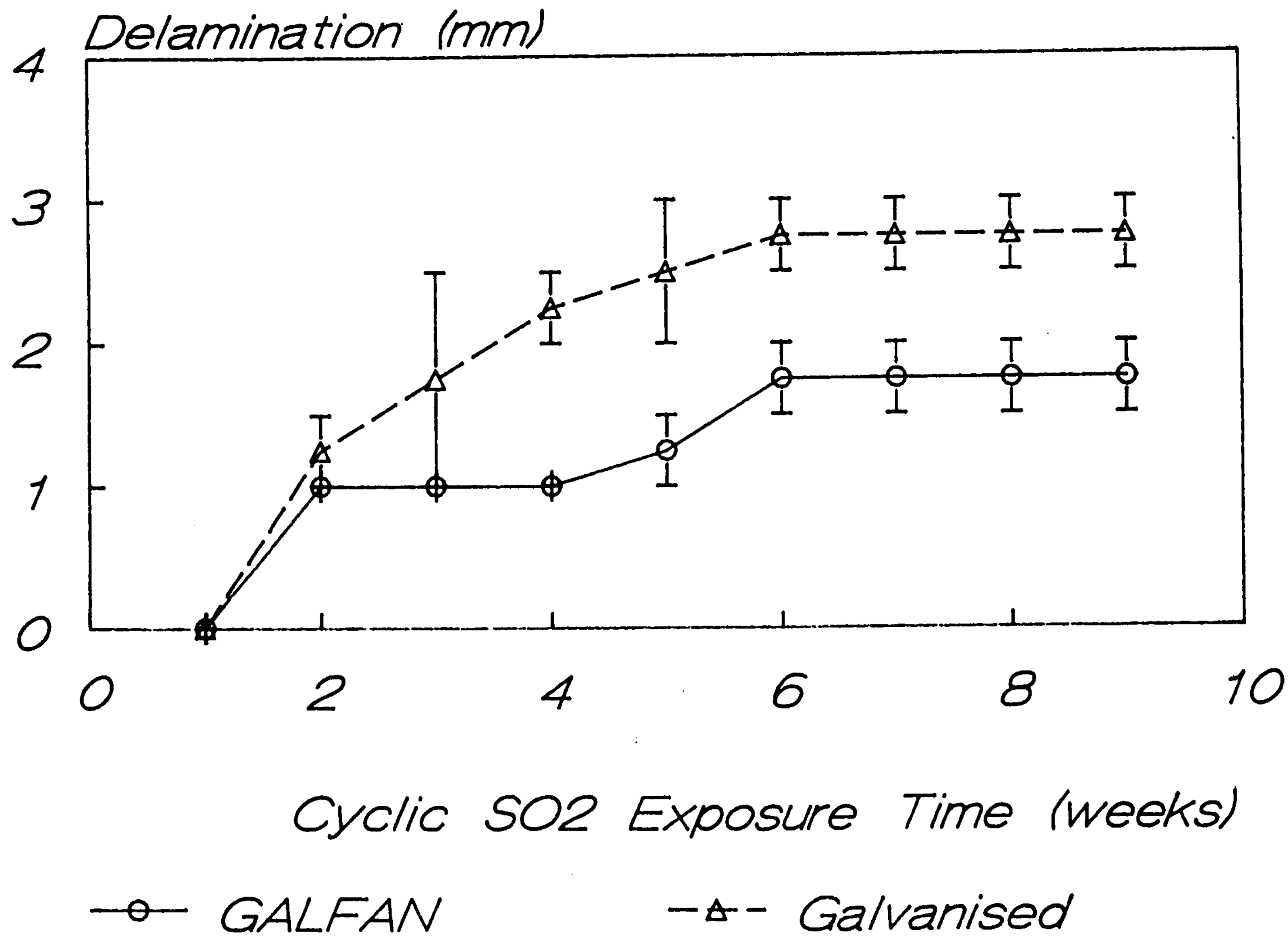


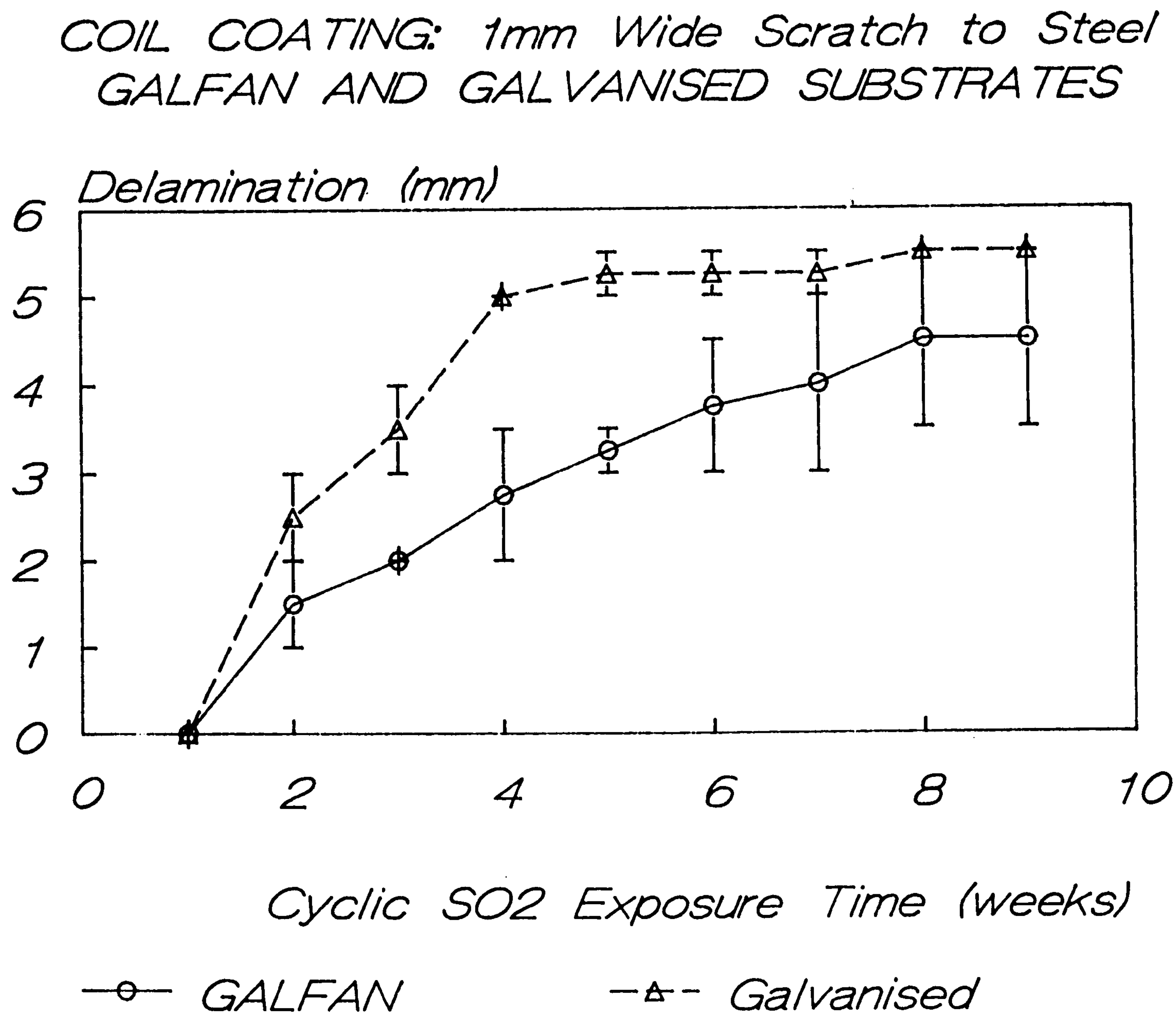
ROLL-FORMING
SO2 CORROSION: Standing Seam Shapes
Time to Red Rust at Folds (Weeks)
30
25
20
15
10
5
0
Oiled
Cr
Cr-Oiled
XSm-Cr-Oil.
Surface Condition
GALFAN
Galvanised

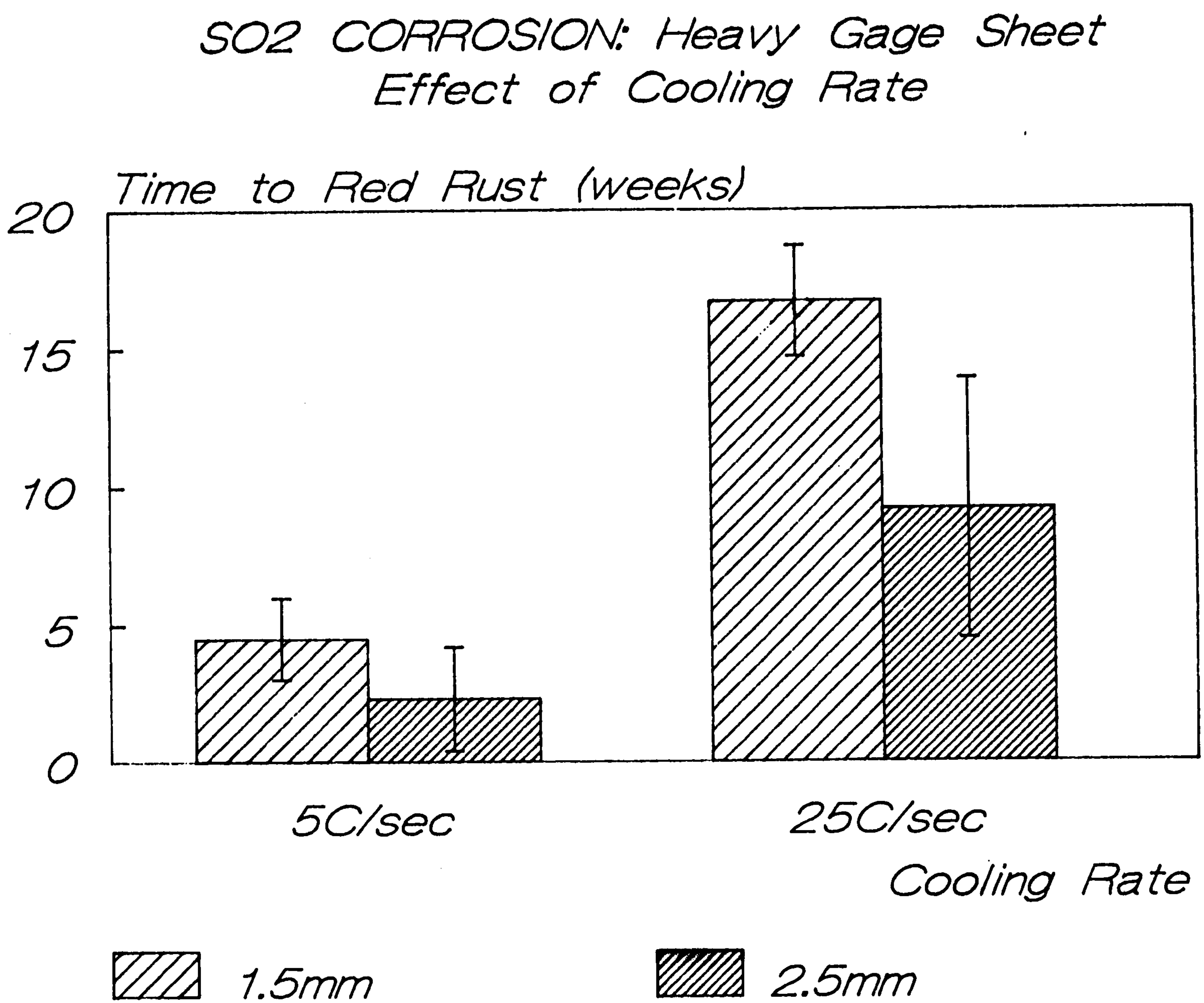
COIL COATING: Flat Specimens
GALFAN AND GALVANISED SUBSTRATES



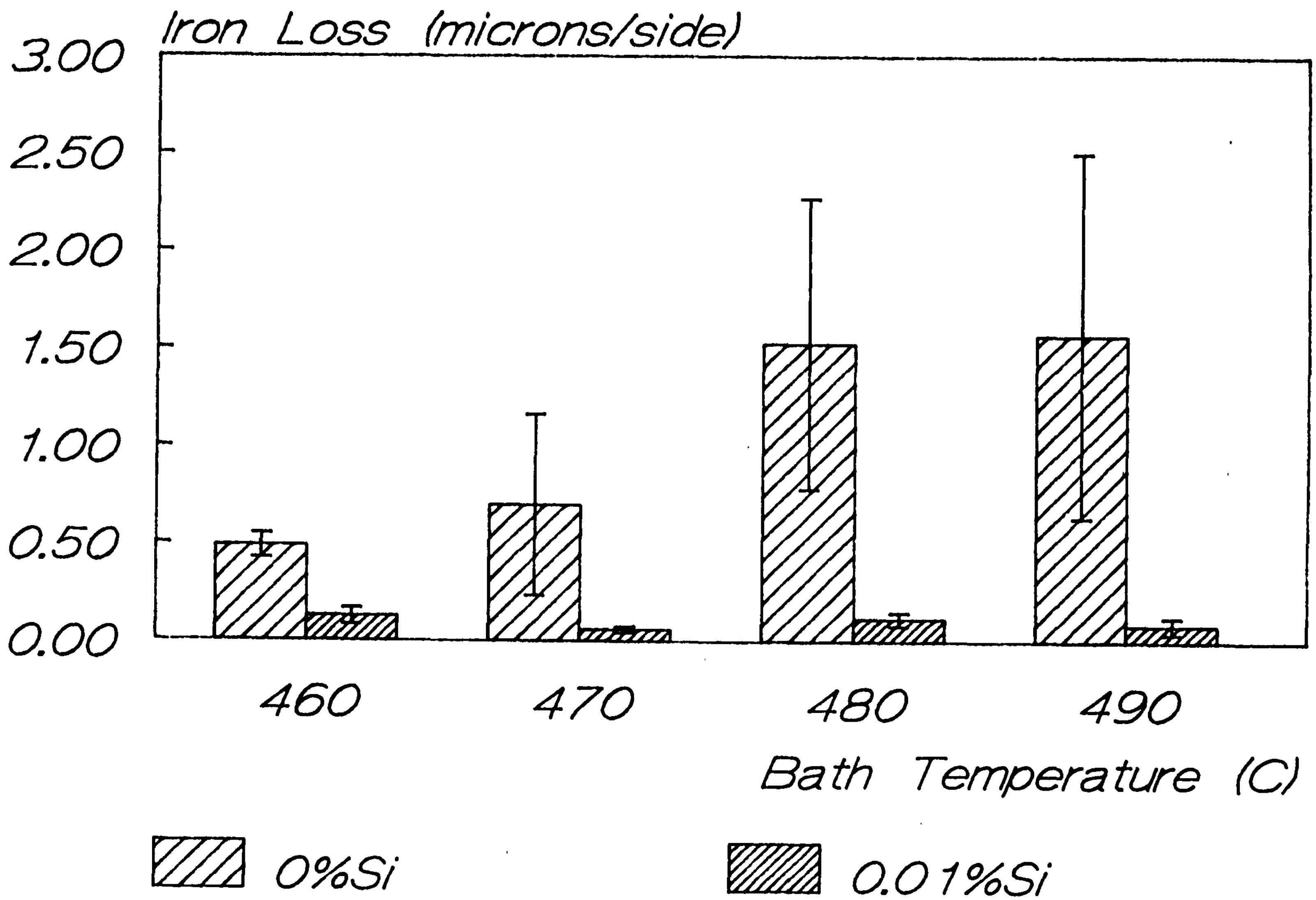
COIL COATING: Cross-Scratched Specimens
GALFAN AND GALVANISED SUBSTRATES



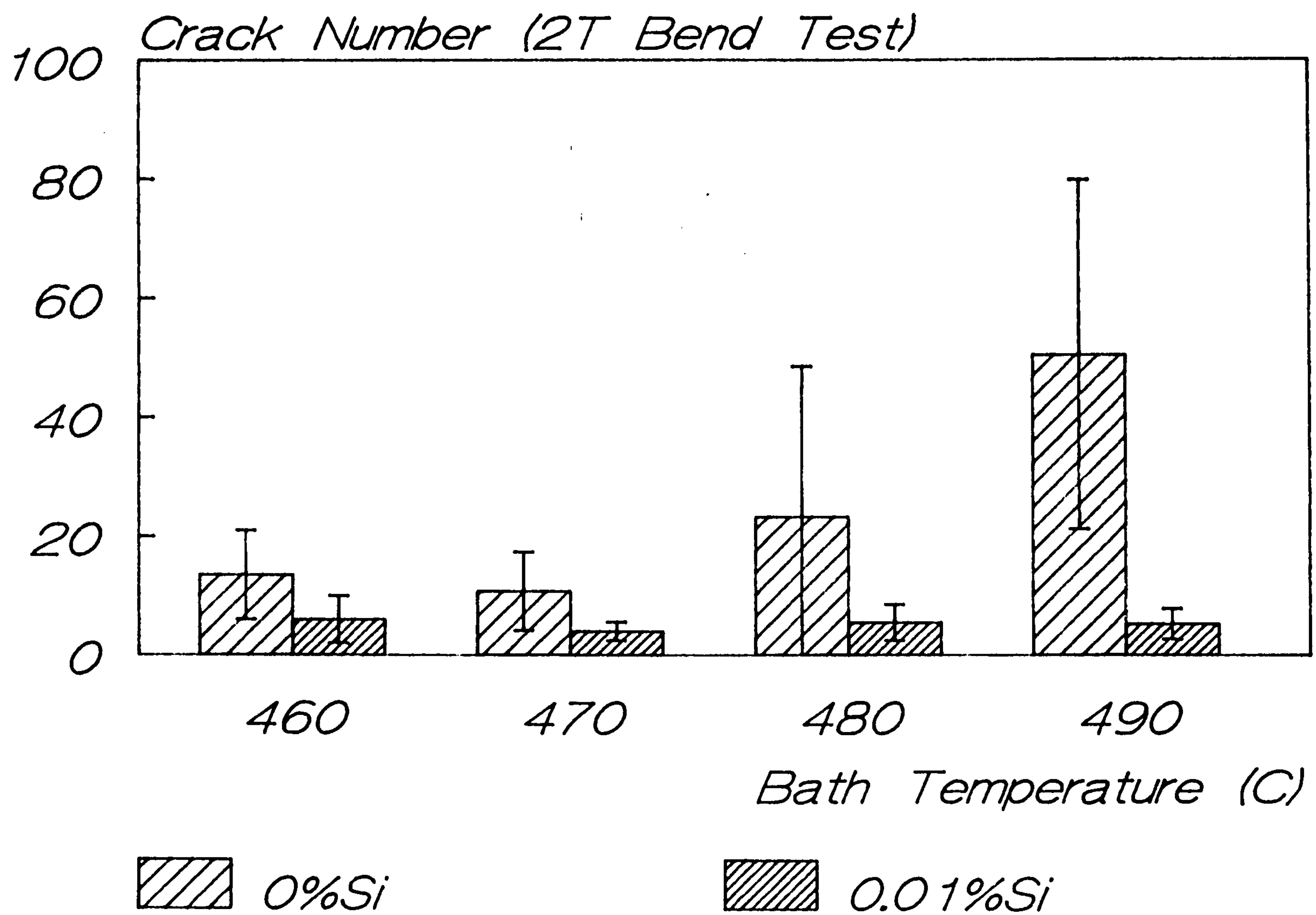

COIL COATING: 1mm Wide Scratch to Steel
GALFAN AND GALVANISED SUBSTRATES
Delamination (mm)
6
5
4
3
2
1
0
0
2
4
6
8
10
Cyclic SO2 Exposure Time (weeks)
GALFAN
Galvanised


SO2 CORROSION: Heavy Gage Sheet
Effect of Cooling Rate
Time to Red Rust (weeks)
20
15
10
5
0
5C/sec
25C/sec
Cooling Rate
1.5mm
2.5mm

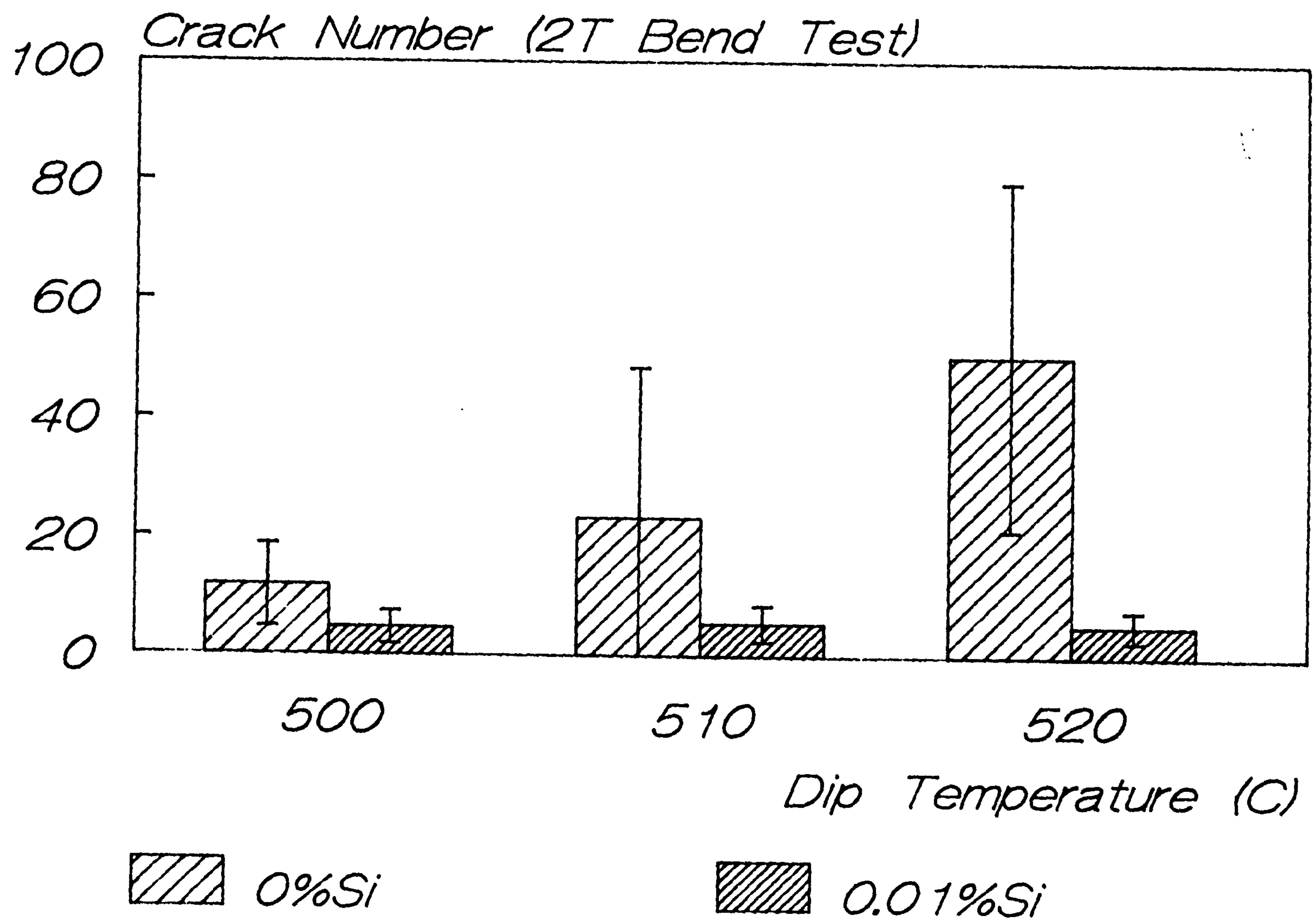
GALFAN HEAVY GAGE STEEL SHEETS
Si ADDITIONS AND BATH TEMPERATURE



GALFAN HEAVY GAGE STEEL SHEETS
Si ADDITIONS AND DIP TEMPERATURE



GALFAN HEAVY GAGE STEEL SHEETS
Si ADDITIONS AND DIP TEMPERATURE



CORROSION RESISTANCE OF ZN-5% AL HOT-DIP COATED STEEL SHEETS

——7-YEAR OUTDOOR EXPOSURE TEST RESULTS

June 5, 1990

Yusuke Hirose

NISSHIN STEEL CO., LTD.

1. Introduction

Nisshin Steel Co., Ltd. is producing Zn-5%Al hot-dip coated steel sheets with a brand "Galtite". At first, we presumed the corrosion resistance of "Galtite" based on outdoor exposure test results of both Zn-Al alloy coated steel sheets by Bethlehem Steel, USA and hot-dip galvanized steel sheets by Nisshin Steel (brand "Pentite B") (Fig. 1, Fig. 2, and Fig. 3). However, the result of 7-year outdoor exposure test revealed that "Galtite" is less corroded than "Pentite B" and that it has longer service life (higher corrosion resistance) than expected. Below is discussed the obtained results.

2. Results

(1) Cross sectional microscopic observation of coated layer of the sample exposed to atmosphere for 7 years revealed that the corrosion depth of "Pentite B" increases linearly with the lapse of exposure time, whereas the corrosion rate of "Galtite" decreases parabolically with the lapse of exposure time. Accordingly, in the first or second year of exposure, there is no significant difference in corrosion depth between them, but as the exposure time elapses (for

example, 5 years, 7 years), the difference in corrosion depth between "Galtite" and "Pentite B" becomes more remarkable (Fig. 4,5)

(2) We calculated the time to red rusting based on the average corrosion rate of coatings for these 7 years and plotted the obtained data on the initially presumed service life curve (Fig. 3) so as to compare them. As a result, it was found that "Galtite" has longer service life than expected in any environment (Fig. 6). Especially, exposure data in industrial environment show that the time to red rusting calculated from the corrosion depth of "Pentite B" and "Galtite" both subjected to 7-year exposure is by far longer than presumed service life. We consider that this is due to the fact that environmental corrosiveness of exposure testing site has become milder than that before.

(3) The difference in corrosion behavior between "Galtite" and "Pentite B" is assumed to be caused by the difference of corrosion products. The corrosion products on "Pentite B" was found to be composed of both zinc carbonate hydroxide and zinc oxide, irrespective of exposure environments (Fig. 7~10). But in the corrosion products on "Galtite" which were exposed

in the three different environments except in severe marine, only the zinc carbonate hydroxide and no zinc oxide was detected. This means that the zinc carbonate hydroxide is formed more stably and easily in "Galtite" than in "Pentite B". In addition, the corrosion products (supposed to be aluminum sulfate hydroxide) consisting of Al-S-O was also detected on "Galtite" (Fig. 11). It is considered that the corrosion of "Galtite" is suppressed as the coated layer is covered by these hydroxides.

(4) From the results of 7-year exposure testings, we got the corrosion resistance ratio of "Galtite" to "Pentite B" in various environments as follows:

- Rural environment ..... 2.04 times
- Industrial environment ..... 2.07 times
- Severe marine environment ..... 2.16 times

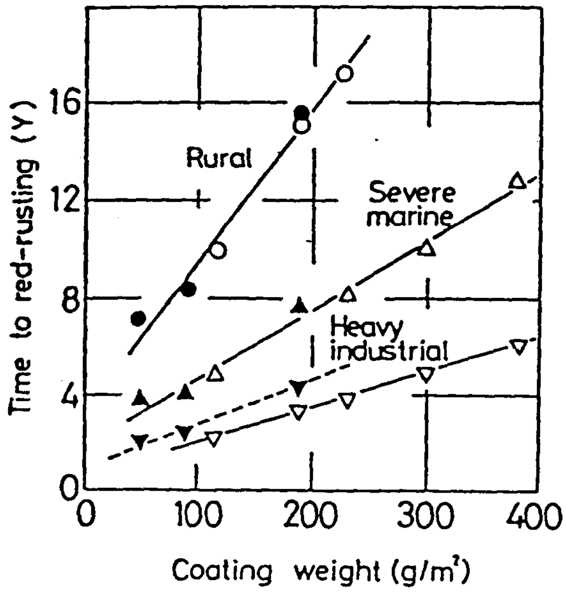


Fig.1 Effect of coating weight on corrosion performance of hot-dip galvanized steel sheet("Pentite B").

○ △ ▽ Data by ASTM,A-5 Committe
● ▲ ▼ Data by Nisshin Steel

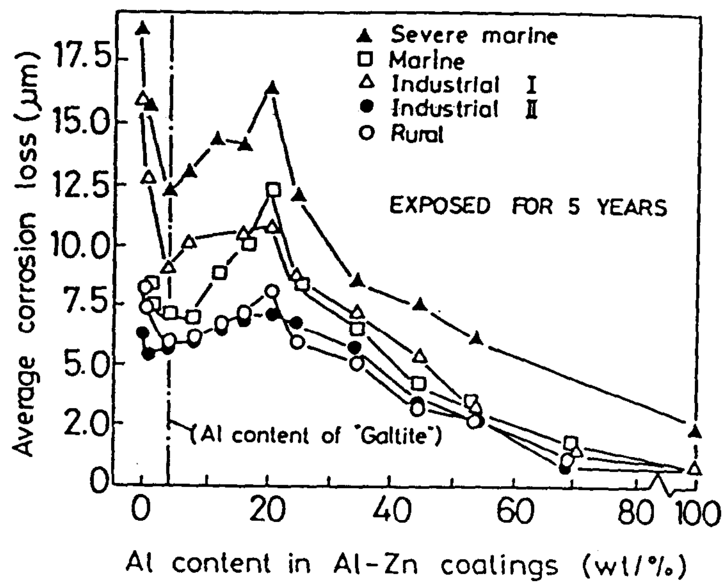


Fig.2 Effect of Al content on corrosion performance of Al-Zn alloy coatings after 5 years' exposure.
+ J.B.Horton:Corrosion control by Coatings,Science Press,(1987),59

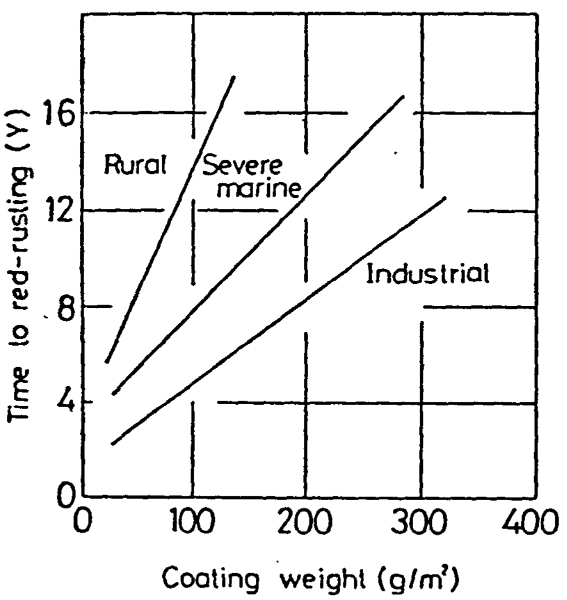


Fig.3 Life estimation to corrosion of "Galtite"(5%Al-Zn) in various environments.

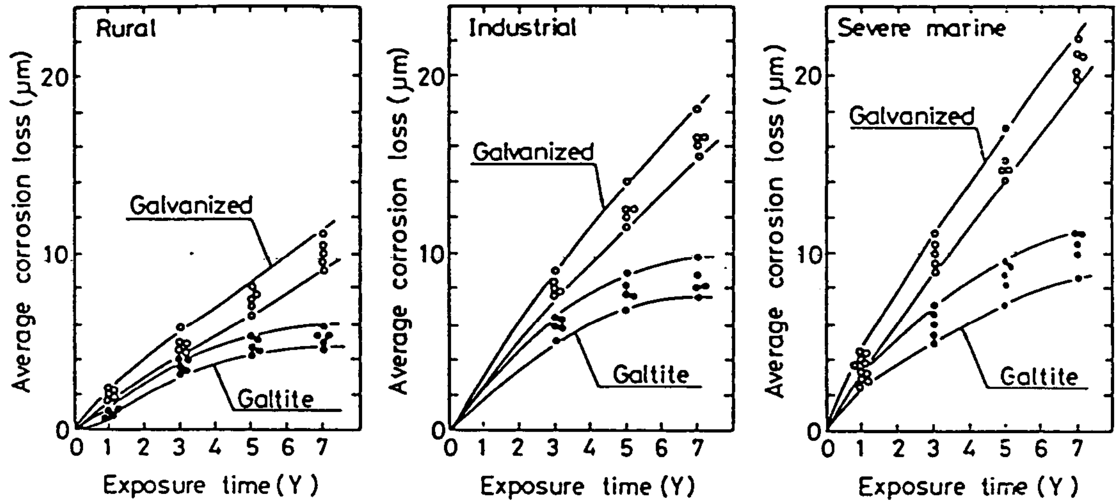


Fig. 4 Corrosion performance of "Galtite" sheets exposed in various environments.

Table Details of test panels

Test panel	Thickness (mm)	Composition of coating (%)			Coating weight (g/m²)
		Al	Pb	Mg	
"Pentite B"	0.35	0.23	0.17	tr.	160
"Galtite"	0.35	4.4	0.003	Small amount	156

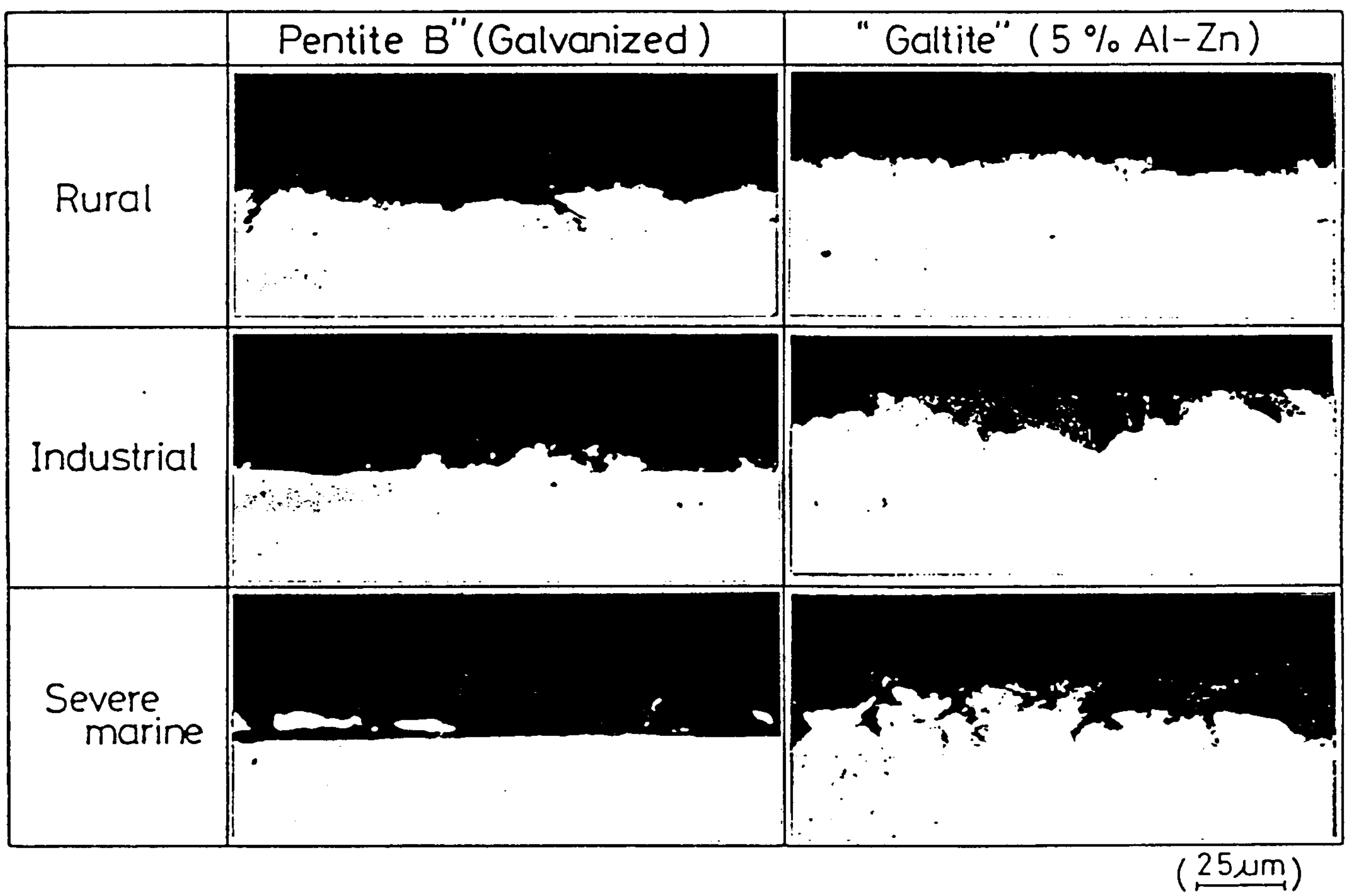


Fig. 5 Cross-sectional microstructures of "Galtite" (5%Al-Zn) and "Pentite B" (Galvanized) sheets exposed for 7 years in various environments.

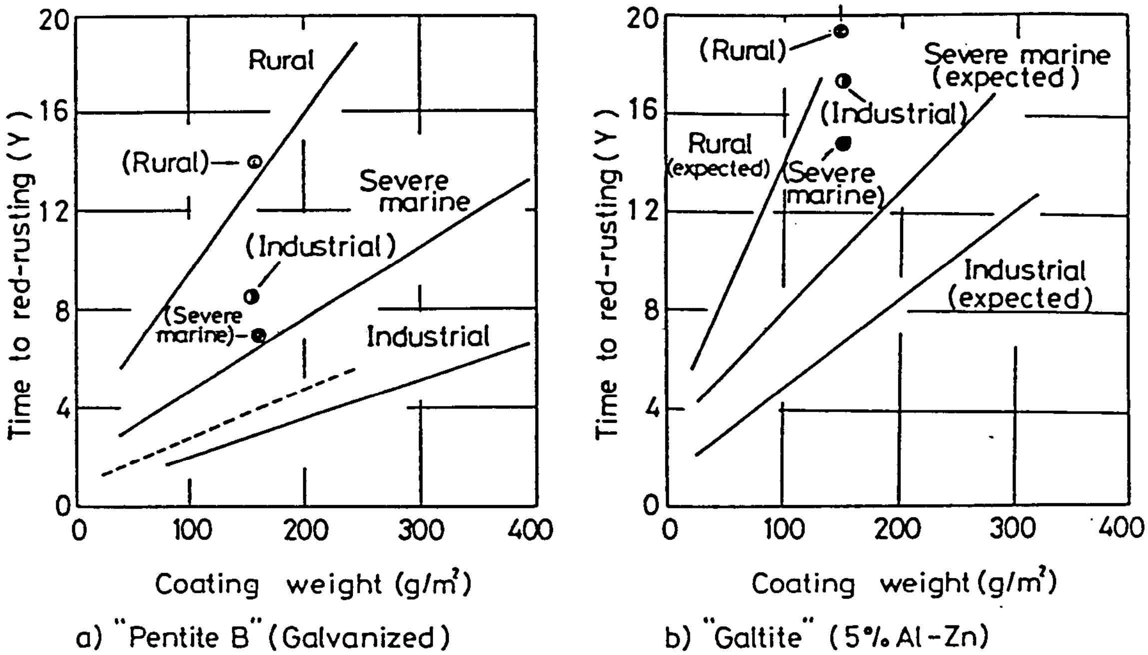


Fig. 6 Comparison between life estimated in Fig. 3 and life calculated from 7 years exposure test results.

○ ◑ ● :life calculated from 7 years exposure results

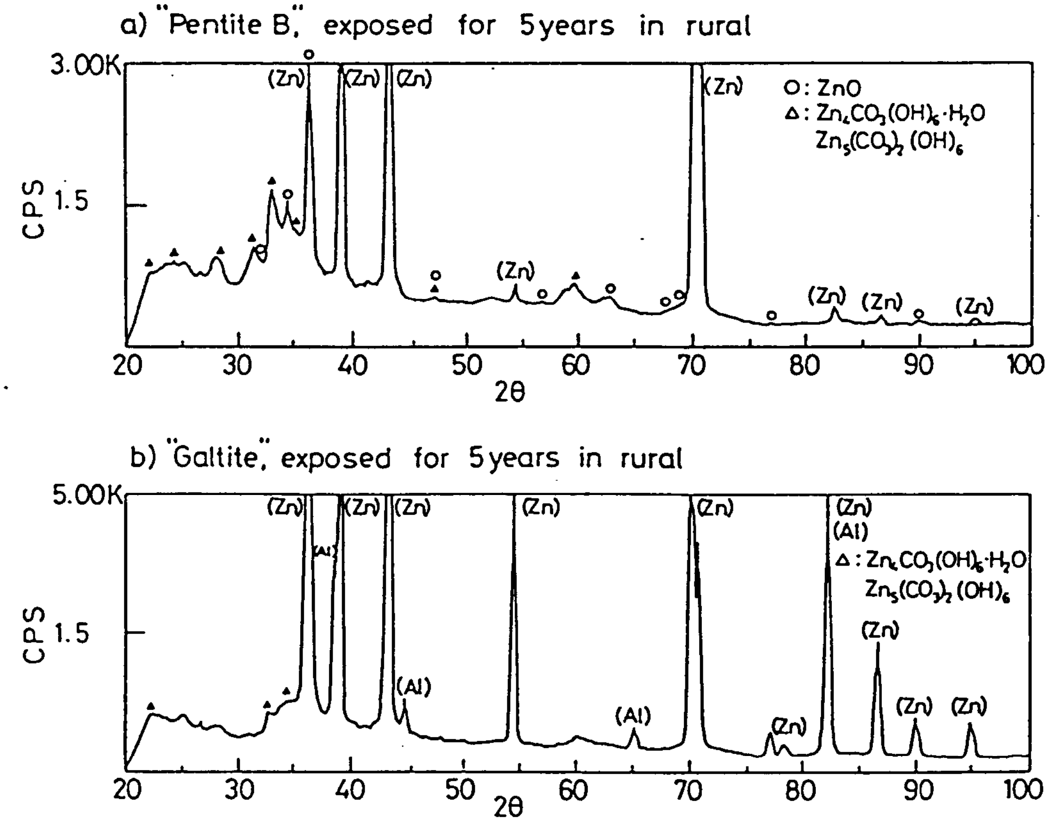


Fig. 7 Corrosion products formed on "Galtite" and "Pentite B" sheets in rural environment.

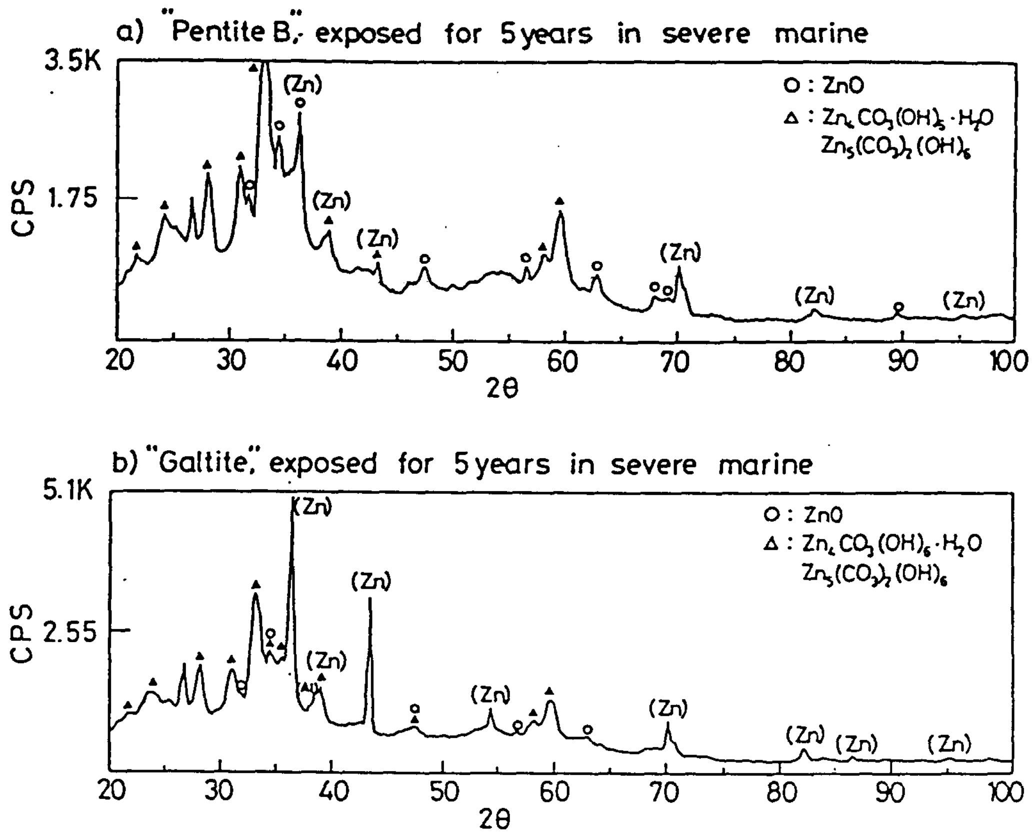


Fig.10 Corrosion products formed on "Galtite" and "Pentite B" in severe marine.

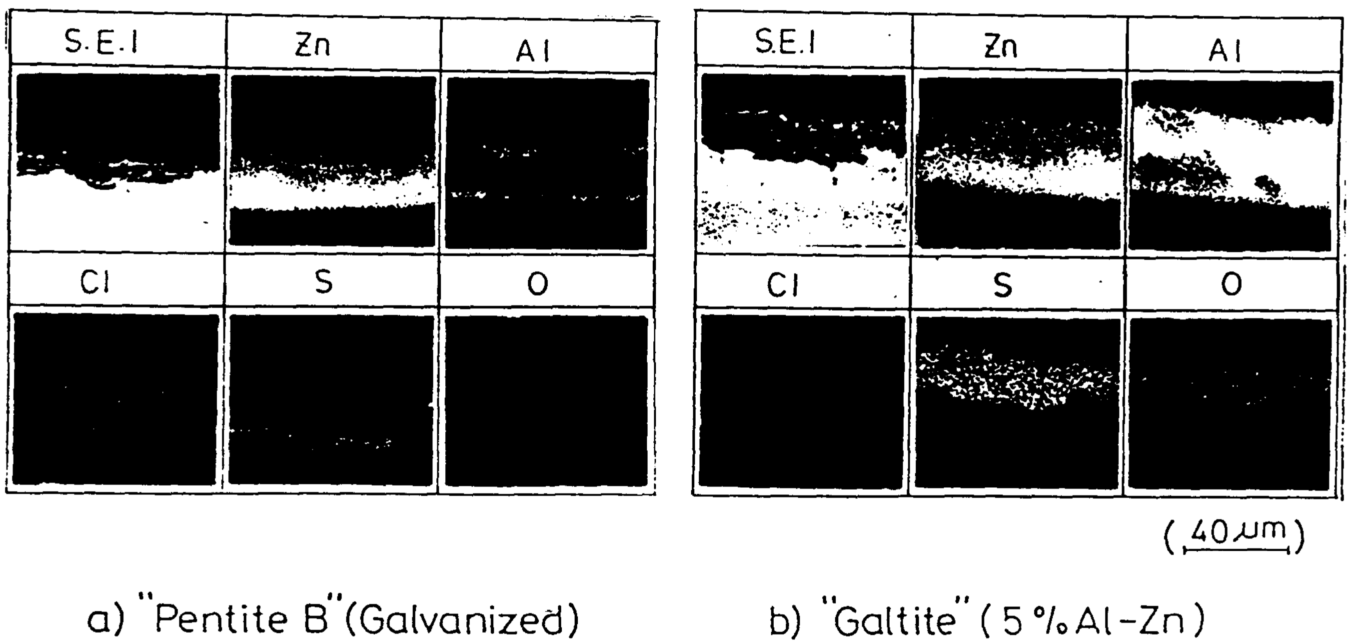


Fig.11 X-ray images of corrosion products formed on "Galtite" and "Pentite B" sheets exposed for 5 years in industrial environment.

GALFAN

8 YEAR EXPOSURE IN NEW ZEALAND

- Bare

-Prepainted

Base material sourced from the first production campaign
at Mouzon 1981.

MANUKAU HEADS EXPOSURE SITE

- SITUATED ON A CLIFF TOP
- SITE FACES DUE WEST
- AVERAGE RAINFALL 1350mm/yr
- AVERAGE SUNSHINE HOURS 2166hrs/yr
- AVERAGE HUMIDITY 82.3%
- PREVAILING WIND STH-WEST
- OFTEN BLANKETED SALT-FOG MIST

Bare Galfan

Points

-Coating weight loss less than Galvanised

-Weight loss not coat weight specific

-Corrosion of Galfan more even across panel face c.f. Galvanised

Prepainted Galfan

Points

-Galfan superior corrosion performance c.f. Galvanised;formed edge,panel face and cut edge protection

-Corrosion performance comparable for range of coating weights

-Selection of paint system important for total product performance

-Prepainted superior performance to that of post painted

MOUZON GALFAN

PREPARATION OF PANELS

ALL PANELS WERE LABORATORY PREPARED

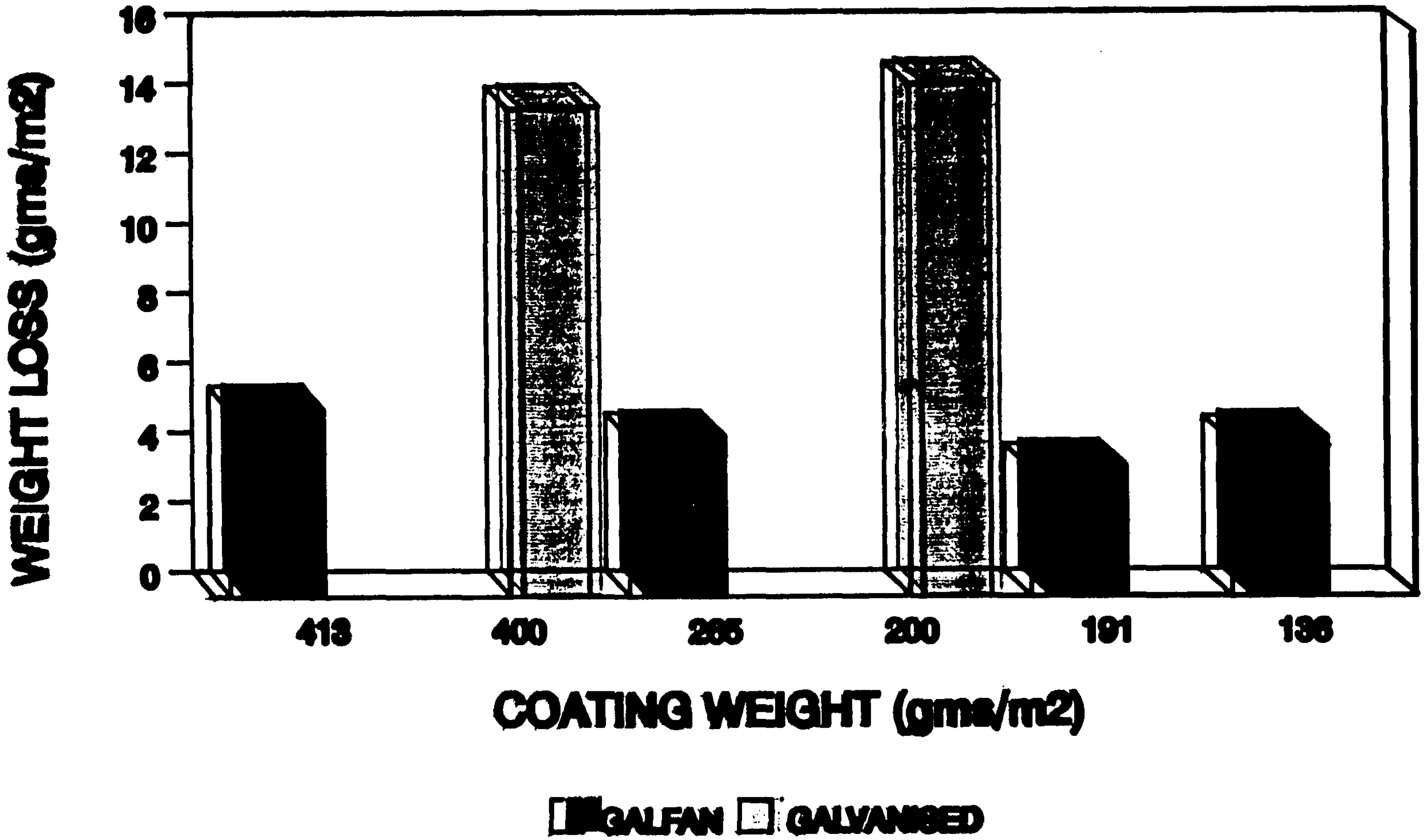
(1) PANELS DEGREASED IN PARCOLENE 336b, CONTACT TIME 20 sec, 6 POINT CONC. @ 70 C.

(2) PASSIVATED IN BONDERITE 1310 CR. SOLUTION, 10 sec. CONTACT TIME, 15 POINT CONCENTRATION

(3) LABORATORY PRIMED/TOPCOATED USING WIRE BOUND APPLICATOR BARS, THE COATING CURED IN A FORCED AIR CIRCULATED OVEN

8 YEAR EXPOSURE - SEVERE MARINE

COMPARSION - GALV. V GALFAN (UNCOATED)



Corrosion Behavior of Galfan Steel Sheets at Edge Portion

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Corrosion performance of prepainted steel sheets at edge portions has been regarded as of major importance. The edge creep caused by underfilm corrosion and the formation of red rust not only spoil the appearance ,but also accelerate the deterioration of prepainted steel sheets.

As the edge corrosion is thought to be characterized by the galvanic corrosion of zinc or zinc-base alloy plated layer as anodes ,corrosion behavior at edge portions may be influenced by area ratio between cathode and anode (C/A) ,where C is the exposed area of substrate steel and A is that of plated layer.

Experimental

1)Specimens

Three kinds of prepainted steel sheets ,Galvalume,Galfan and galvanized steel sheets were used in the present study [Table1].

Specimens designed for electrochemical measurement were prepared by embedding the prepainted steel sheets in epoxy resin with the one side edge exposed to corrosion environment [Fig.1(a),(b)].

In order to investigate the influence of C/A ratio on corrosion behavior of prepainted steel sheets at edge portions ,the cathode area was properly increased by attaching thin steel sheets to the piece of prepainted steel sheet [Fig.1(c)].

Table1. Materials used for the experiment

	Galvalume	Galfan	Galvanized
Thickness Plating/Substrate (μm)	40/370	48/500	42/480
Pretreatment	Chromate (60mgCr/m^2)	Phosphate (1.0g/m^2)	
Primer	Epoxy urethan		
Top coat	Oil-free polyester		

2)Cyclic corrosion test

Corrosion behavior of prepainted steel sheets at edge portions was investigated by the cyclic corrosion test, consisting of immersing in 0.05% NaCl solution (35℃), drying and humidifying at 85%R.H. (50℃).

3)Electrochemical measurements

Corrosion behavior of the specimens was monitored by measuring the corrosion potential (Ecorr) and polarization resistance (Rp), when the specimens were immersed in 0.05% NaCl solution under the cyclic corrosion test. The polarization resistance was measured by a.c. impedance method, using the potentiostat supported by frequency response analyzer.

Results and Discussion

Change of corrosion potential (Ecorr) with corrosion testing time are shown in Fig.2~4, for Galvalume, Galfan and galvanized steel sheets respectively. The corrosion potential of Galvalume steel sheets was most noble, about 100mV higher than that of the others in the case of lower C/A ratio (presented by closed circles in Figures).

It was also found that the corrosion potential changed largely as the corrosion test progressed, when C/A ratio was higher.

The appearance of rust formed on the edge portions exposed to corrosion environment was observed. The results are shown in Table2. When the C/A ratio was high, large amounts of red rust were found, which were considered to be produced by corrosion of the substrate steel.

Therefore the rapid change of corrosion potential shown in Fig.2 ~4 corresponds to the occurrnce of corrosion of substrate steels.

Table2. Appearance of rust formation at edge portions

	C/A=9~12	C/A=18~24	C/A=37~44
Galvalume	− (+)	+++ (+)	+++ (++)
Galfan	+ (−)	+ (+)	+ (+)
Galvanized	++ (+)	++ (+)	+ (+++)

white rust (red rust)

−: Little rust was observed

+→++→+++: Amounts of rust increased

The relation between polarization resistance(Rp) and C/A ratio of prepainted steel sheets at edge portions is shown in Fig.5. At the initial stage, Rp showed a tendency to decrease as C/A ratio increased. Particularly the dependence of Rp on C/A ratio was marked for Galvalume steel sheets. The Rp of Galvalume was very high when C/A ratio was equal to 9.2 ,but extremely decreased as C/A ratio increased. On the other hand ,Galfan and galvanized steel sheets did not show such a extreme tendency for Rp to decrease. Simillar tendencies were found after cyclic corrosion test was performed [Fig.5 (b)].

Assuming that Rp corresponds to corrosion resistance ,the corrosion resistance of Galvalume steel sheets with lower C/A ratio is expected to be most excellent. But when C/A ratio is higher ,the corrosion resistance of Galfan is superior to the other steel ,Galvalume ,Galvanized steel sheets .

Conclusions

Influence of cathode/anode area ratio on the corrosion behavior of prepainted Galfan steel sheets at edge portions was investigated by a cyclic corrosion test ,using electrochemical techniques. It was found that the corrosion resistance of Galfan is expected to be most excellent of the three materials in higher C/A ratio. Therefore Galfan is more suitable to heavy gage prepaint steel seets than other two materials ,Galvalume Galvanized steel seets.

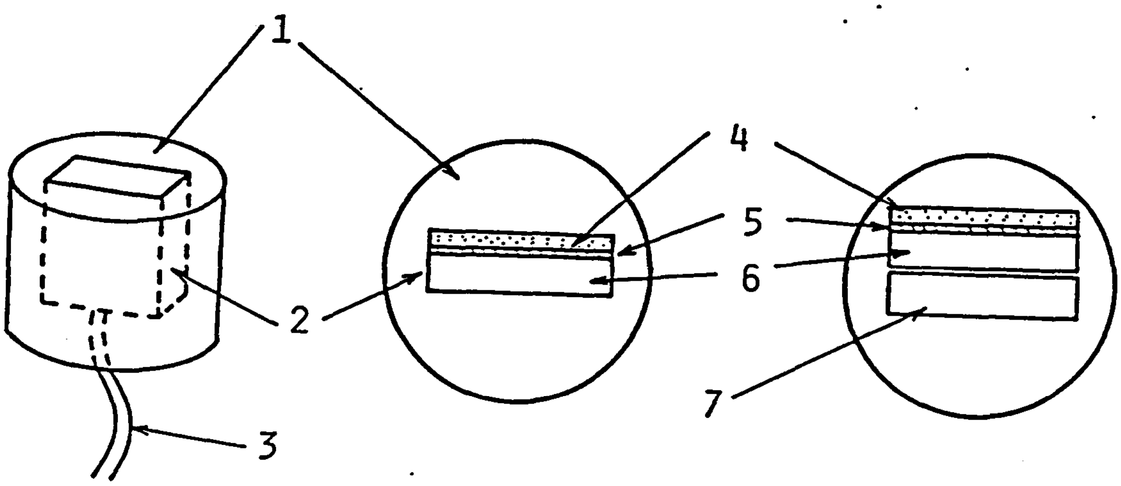

Fig. 1 Schematic illustration of the specimens used for electrochemical mesurement.
1 : Epoxy resin, 2 : Zn/Zn-Al alloy plated steel sheet with paint film, 3 : Lead wire, 4 : Paint film, 5 : Zn/Zn-Al alloy plated layer, 6 : Steel substrate, 7 : steel sheet

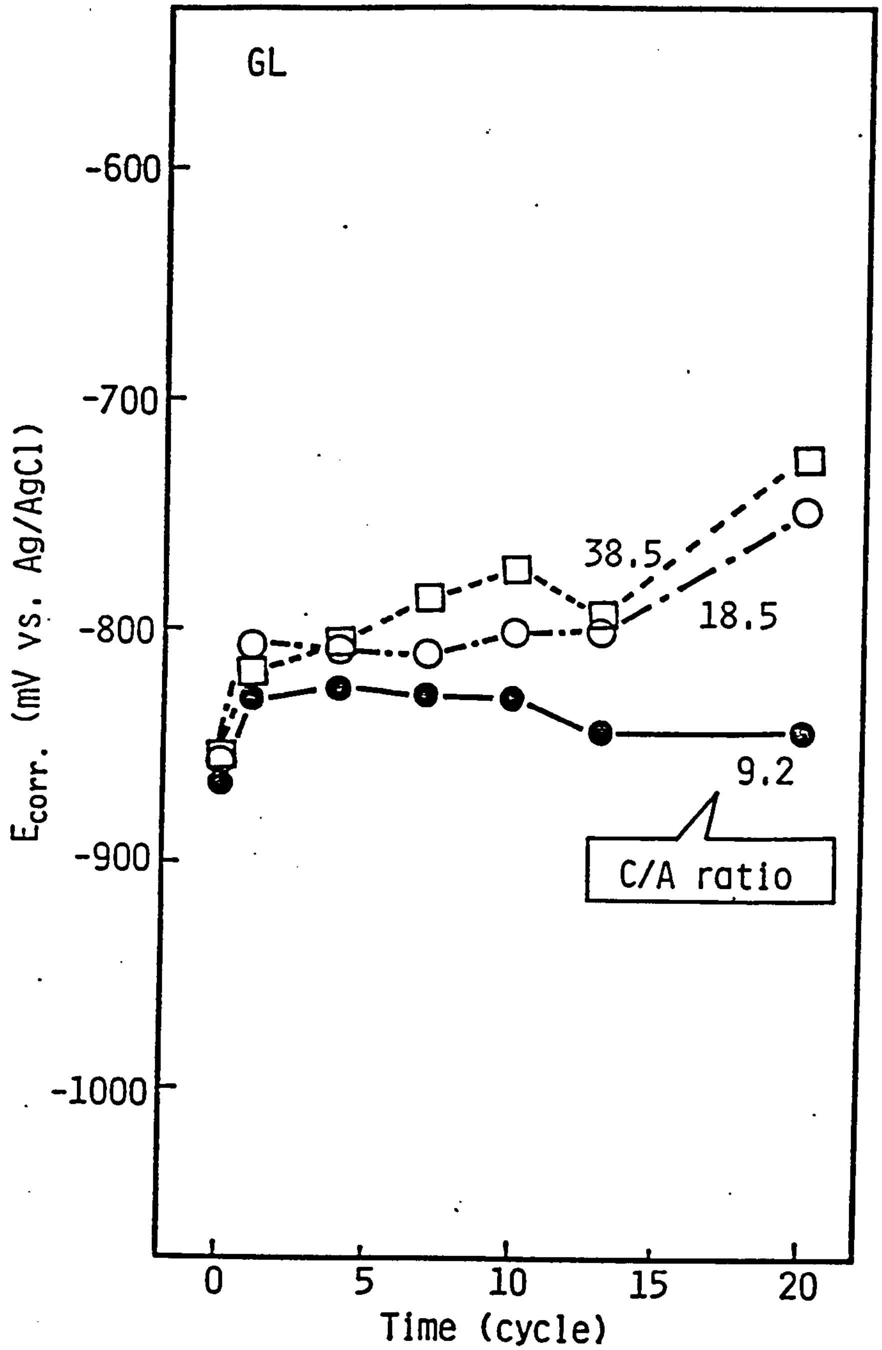

Fig. 2 Change of corrosion potential ($E_{corr.}$) with corrosion testing time for Galvalume steel sheets.

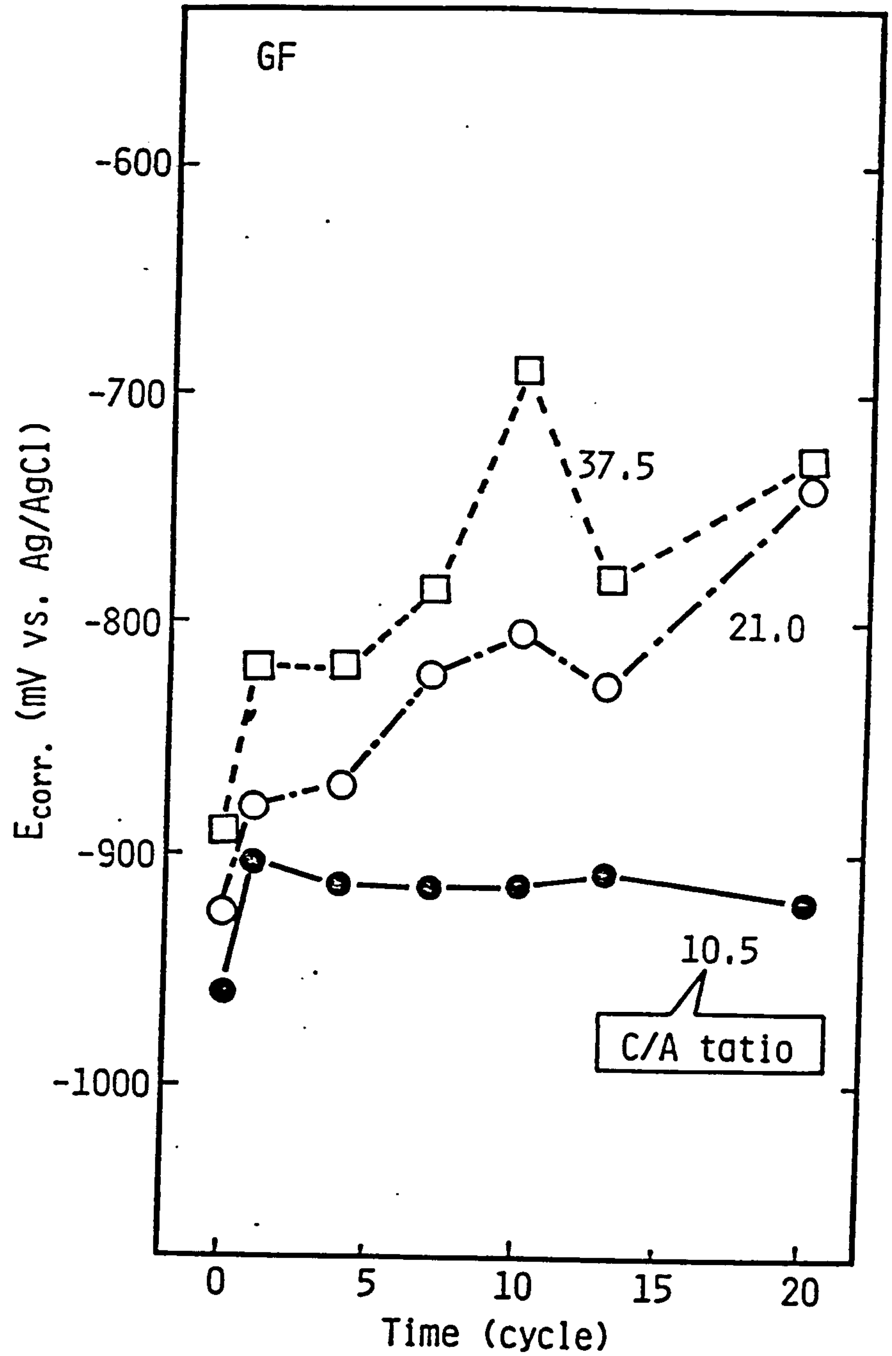

Fig. 3 Change of corrosion potential ($E_{corr.}$) with corrosion testing time for Galfan steel sheets.

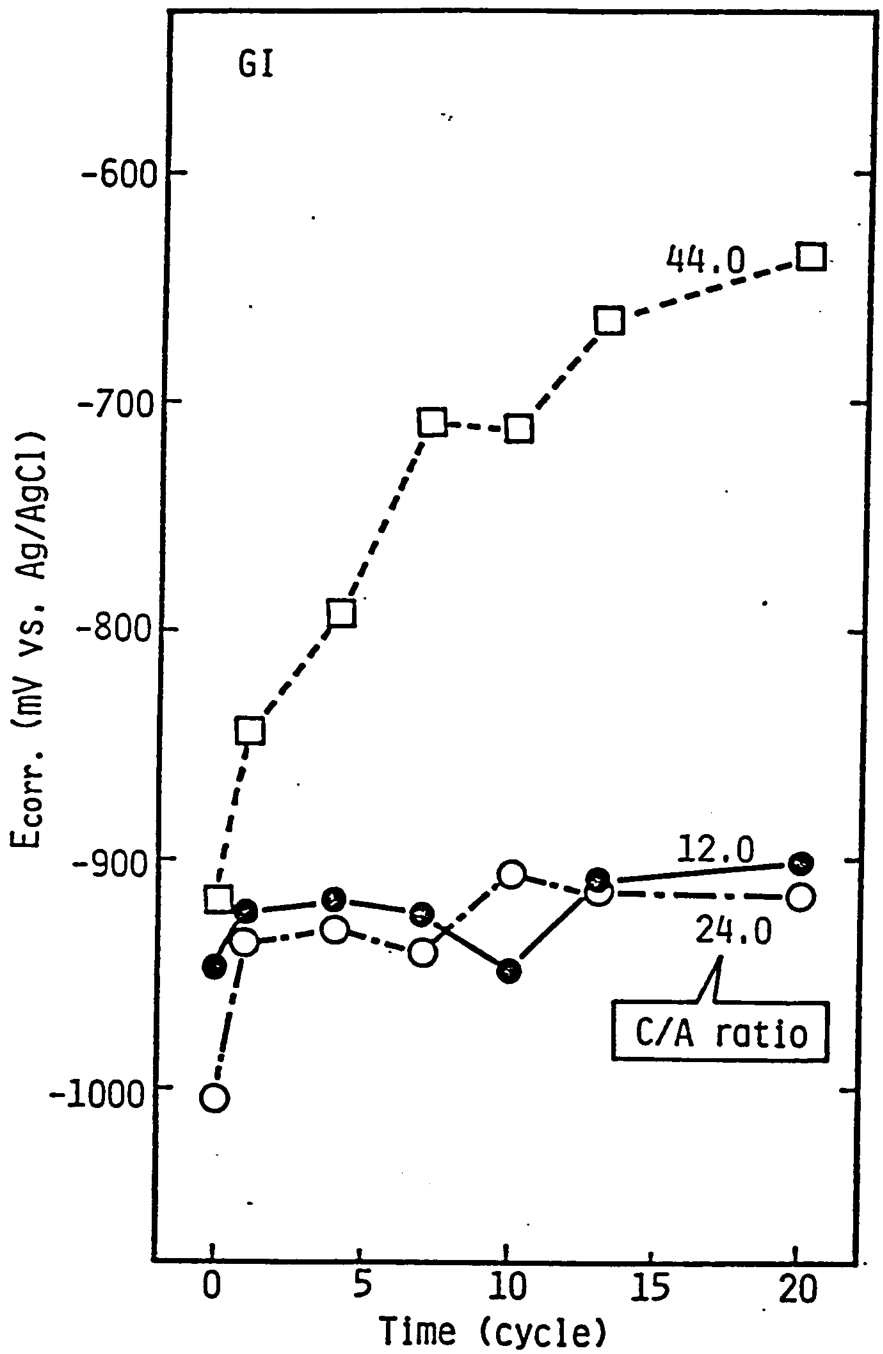

Fig. 4 Change of corrosion potential ($E_{corr.}$) with corrosion testing time for galvanized steel sheets.

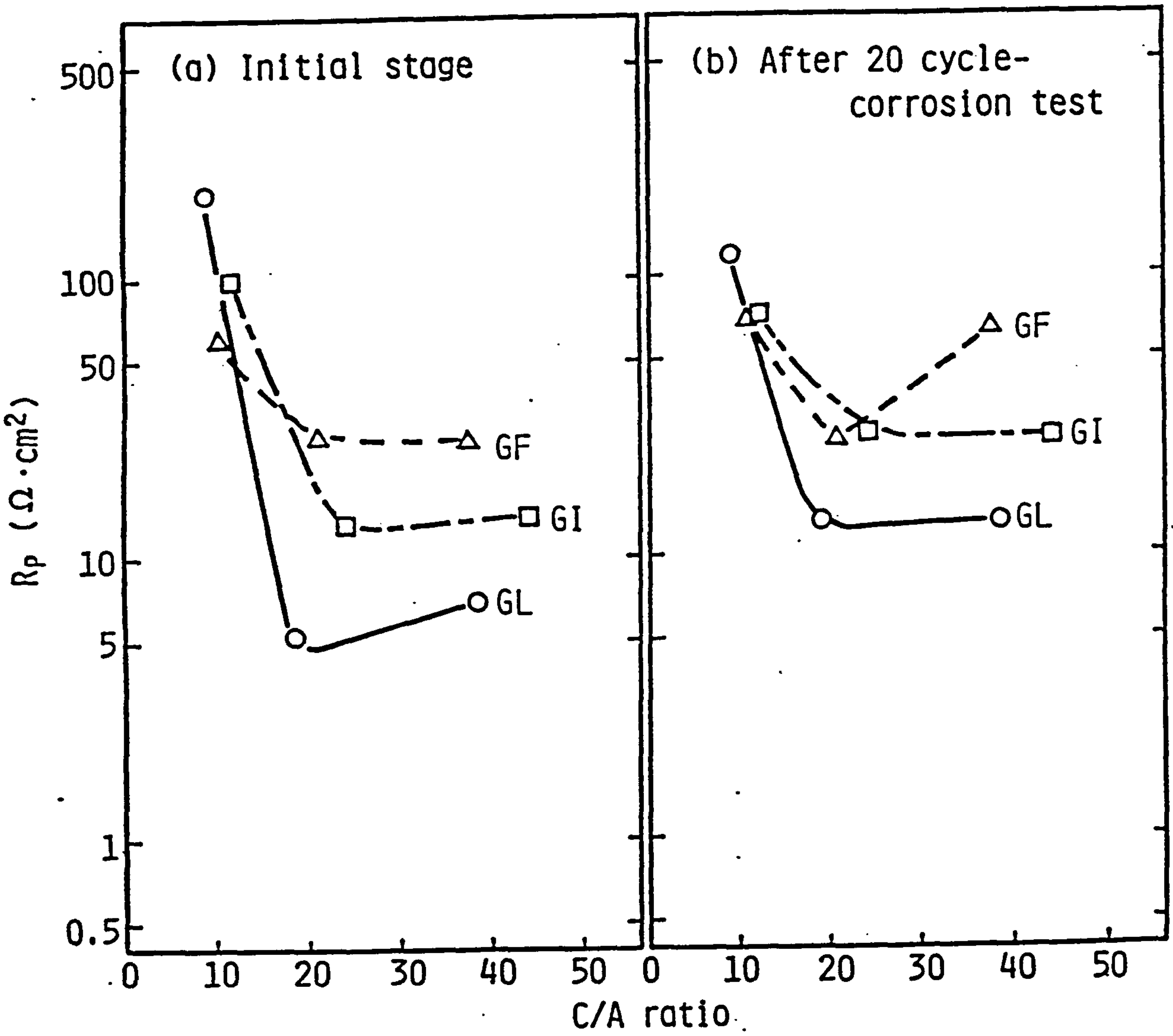

Fig. 5 Dependence of polarization resistance (R_p) on cathode/anode (steel/plated layer) area ratio.

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A new generation of corrosion protective coating

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Introduction

Galvanized steel is (and certainly will remain) one of the most cost-effective materials for the application of products requiring protection in most corrosive environments. However, in those cases where classic galvanizing is not adequate to meet more severe environmental (e.g. marine atmosphere) or manufacturing (primer, painting...) demands, several new coating systems are now offered.

Another impetus for the search for coatings with improved corrosion resistance was the growing awareness of the fact that corrosion was becoming more and more the primary factor for troubles, breakdowns and malfunctioning. This can be related to increased industrial emissions making atmospheric conditions more and more agressive (e.g. the "acid rain").

Research for more durable metallic coatings for steel sheet and wire has focussed on the Al-Zn system. During 1979, CRM (Centre de Recherches Métallurgiques) in Belgium started research sponsored by ILZRO on the eutectic 95 % Zn / 5 % Al system. GALFAN, a 95Zn/5Al + mischmetal (La-Ce) hot dip alloy coating has found rapid acceptance in different countries all over the world, being characterized by a unique combination of formability and superior corrosion resistance (1) (2) (3)

Bekaert, the world largest independent producer of steel wire and steelwire products has packed all of its coating knowhow into a brand-new line of GALFAN products, marketed under the brand name BEZINAL. Extensive laboratory testing of these BEZINAL products showed that the corrosion resistance was at least two to three times higher than that of steel galvanized in the classic way. These results are gradually confirmed by production applications.

1. Accelerated laboratory corrosion testing.

BEZINAL products have been extensively evaluated, using standard accelerated tests such as salt spray, SO_2. Moreover for certain specific applications, accelerated tests were elaborated, simulating the particular conditions e.g. testing of vineyard wire in a slurry of herbicides and fungicides ; testing of nettings for mink farming with food slurries.....

All these accelerated tests were performed on samples taken from the production line (galvanizing line, Bezinal line). Characteristics of representative samples are given in table 1.

Sample	Ref.	Diam.(mm)	Coating weight(g/m^2)	Type
Bezinal 1	B1	1.95	323	as coated
Galvanized 1	G1	1.95	386	as coated
Bezinal 2	B2	3.60	300	as coated
Galvanized 2	G2	3.60	342	as coated
Bezinal 3	B3	1.39	124	redrawn/B2
Galvanized 3	G3	1.39	148	redrawn/G2

Table 1. Characteristics of samples used in corrosion tests.

1.a. Salt spray testing. ASTM B117.

The results of the salt spray tests for the corresponding samples from table 1 are given in figs. 1 to 3.
Whatever criterion is taken, it is entirely clear from these figures that the basic corrosion resistance of the Bezinal coating in this 5 % NaCl environment is much better than that of steel galvanized in the classic way :

- the time to initial red rusting of Bezinal is about two times (as coated products) and four times (redrawn wire) that for the corresponding galvanized samples with even a higher coating weight. Using the K-value as criterion for corrosion resistance (K = time to initial rusting divided by the initial coating weight) gives the following classification:

- Bezinal as coated: K = 4 and 4.4
- Galvanized as coated: K = 1.6 and 1.8
- Bezinal redrawn : K = 4.7
- Galvanized redrawn: K = 0.9

These K-values signify that the intrinsic corrosion protection "value" (intrinsic : for a same coating weight) of Bezinal coatings is 2,5 times that for classic galvanization for as coated products and even 5 times for redrawn wire.

- the course of the curves indicating the loss of weight during the test, equally proves the clearly better corrosion resistance of Bezinal compared to classic galvanization. Furthermore, these curves show that, except for redrawn Zn, the speed of the decrease in weight is not constant over the entire duration of the test. One can clearly distinguish two areas, for which the corresponding corrosion rates have been computed ($g/m^2/100$ hours).

Sample B1: 32 and 9	Sample G1: 58 and 26
Sample B2: 25 and 9	Sample G2: 55 and 22
Sample B3: 28 and 10	Sample G3: 127

Table 2: Corrosion rates (g/m^2 100 hours) from weight loss figures 1, 2 and 3.

Those values prove that the initial corrosion rates for Bezinal fall in the course of the test back from about 28 $g/m^2/100$ hours to about 9 g/m^2:100 hours. This decelerated corrosion occurs for all the tested Bezinal samples, so for the as coated as well as the redrawn ones.

An analogue phenomenon appears to occur for the classic galvanization as coated, with a drop of the initial corrosion rate from about 55 $g/m^2/100$ hours to about 25 $g/m^2/100$ hours. These values confirm once more the conclusion that the corrosion resistance of Bezinal is twice as high as that of the classic galvanization. Moreover, this shows clearly that redrawing has a different influence on the corrosion resistance Redrawing appears to have no influence on Bezinal (both corrosion rates stay the same). On the contrary, for classic galvanization redrawing results in a strong increase of the corrosion rate : from about 55 $g/m^2/100$ hours to 127 $g/m^2/100$ hours, or a factor of 2.5. Redrawing has also an added influence on the corrosion mechanism, as the deceleration of the corrosion rate for as coated samples,which occured during the test, is no longer noticeable for the redrawn samples.

In addition to the conclusions mentioned above about the intrinsic corrosion resistance, those salt spray tests furnish interesting data about the cathodic protection property of both coating systems.

One of the principal advantages of classic Zn coatings is their ability to avoid rusting in scratches on the coating, by means of cathodic protection (the remote zinc effect). It goes without saying that this property must at all costs be preserved in the compared Bezinal coatings. The accelerated corrosion in the salt spray test offers us a possiblity to evaluate the cathodic protection property or at least to evalutate a related variable. The residual coating that is still remaining at the moment that the first rust spot occurs, gives us a clear indication of the "efficiency" with which the remaining coating can continue to protect the steel substratum against corrosion. The weight of the residual coating of the different samples is given in table 3, in g/m^2 as well as converted to micrometer (density Zn : 7,2, density Bezinal : 6,6). This table gives also a number of relevant microstructural characteristics, which have been determined on the sample before the salt spray tests were carried out (discussion microstructure : see infra).

Sample	Residual coating g/m^2	μm	Thickness intermet. layer μm	Thickness Al/Zn or Zn layer μm
B1	20	3	4 - 5	51 - 60
G1	111	15	8 - 10	41 - 62
B2	29	4	4 - 5	44 - 48
G2	141	20	8 - 10	64 - 78
B3	5	1	2	20
G3	41	6	3	24 - 26

Table 3: Residual coating thickness and microstructural characteristics of salt spray samples.

The values given in table 3 are important within the scope of the research on the corrosion mechanism of these coatings. The results of our research in that matter will be the subject of a separate publication.

However, these values can equally be used as a basis of comparison for the protection property of Bezinal coatings compared to the classic galvanization layers. When one starts from the known fact that the classic Zn coatings offer a very good cathodic protectic ability to the underlying steel substratum, one will discover that these values show that Bezinal exceeds this protection ability.

For, where for as coated Zn layers, rusting occurs at a residual coating thickness of 15 to 20 μm, for similar Bezinal products, rusting only occurs at a residual coating thickness of 3 to 4 μm. This is of course very exceptional and means that rusting only occurs at the moment that the Zn/Al layer is as good as completely corroded and when only the intermetallic Zn/Al/Fe layer remains. A tentative explanation for this would be, that the true cathodic protection with Bezinal, is offered by the Zn/Al surface layer. Once that this surface layer is sacrificially corroded, even if it's local, the underlying Zn/Al/Fe intermetallic layer is exposed, thus creating a couple, in which the intermetallic layer is more noble (more cathodic) than the Zn/Al layer. This puts off the penetrating corrosion to the steel substratum till the moment that nearly all of the Zn/Al top layer is corroded.

This mechanism seems to apply just as much for redrawn Bezinal. The residual coating of these samples is also of the same order of magnitude of the Zn/Al/Fe intermetallic layer.
Note that this thickness is only 1 μm, which clearly emphasizes the exceptional cathodic protection property of Bezinal.

1.b. Sulphur Dioxide Accelerated Tests

Two types of accelerated tests have been used to determine the SO_2 corrosion resistance of Bezinal compared with classic galvanized samples. For sample characteristics, see table 1.

The Kesternich test SFW 2.0 S (DIN 50018) uses 2 litres of SO_2 in the 300 litres test chamber. In this very agressive environment for Zn-base coatings, the difference in SO_2 corrosion resistance between Bezinal coatings and galvanized samples was negligible. By using 1 litre of SO_2 instead of 2, differentiation into SO_2 corrosion behaviour became more clear. Figs. 4, 5 and 6 give the results of this modified SO_2 test. The weight loss of the Bezinal coatings is about two times less than that of galvanized wire.

These results indicate that the much better corrosion resistance with Bezinal in the more real life like conditions of SO2 have to be related to the stable passivation by alumina in the resisting coating.

The results discussed above were obtained on the wire samples from table 1. For numerous applications, these wires are used as welded nettings. Fig. 7 shows that the better SO_2 corrosion resistance of Bezinal is maintained in these welded structures.

1.c. Accelerated tests simulating particular applications.

A. Testing of vineyard wire was performed in a slurry of commercial fungicides, herbicides and very fine china clay.
The samples (see table 1) were rubbed with the slurry and tested in a 100 % relative humidity at 30 °C. The loss of weight of the samples galvanized in the classic way was two times that of the Bezinal wires. Moreover, the Bezinal samples retained a high degree of smoothness, which is very important for this particular application.

B. Testing of nettings for mink farming was performed in a slurry of mink food, which was moistened at regular intervals. The loss of weight of all samples was to a great extend determined by the pH-value of the food. Fig. 8 shows the results for a food sample with a pH-value of 6.9. In the initial period, the loss of weight of Bezinal is higher but probably due to passivation phenomena, the corrosion rate slows down whereas the Zn coatings maintain a linear rate. The resulting weight loss after 5 weeks testing is 1.5 times higher for samples galvanized in the classic way than for Bezinal. This advantage remains when using food samples with a more acid reaction. Fig. 9 gives the results for a food sample with a pH-value of 5. The resulting weight loss after 5 weeks testing was doubled for all samples, with again a better result for the Bezinal sample.

2. Microstructural features.

Without going into details about the influence of the microstructure on the corrosion mechanism, it has to be emphasized that a "correct" microstructure of the Zn/Al coating is essential for a good corrosion behaviour of the Bezinal products.

Fig. 10 gives the Zn/Al diagram. The best corrosion resistance is obtained with the eutectic composition. For optimum corrosion resistance, a very fine eutectic structure without secondary phases or precipitates in the grain boundaries is absolutely necessary. All processing parameters must be under control to guarantee the very fine eutectic microstructure and to minimize the grain sizes also in real production circumstances.

Fig. 11 shows the microstructure of sample B2: an intermetallic Zn/Al/Fe layer (thickness 4-5μm) at the steel-coating interface and a very fine lamellar Zn/Al eutectic (fig. 12).

As discussed above (1.a. Salt spray testing), the intrinsic corrosion resistance of the Bezinal coatings in this NaCl environment is much better than that of the products galvanized in the classic way. Scanning Auger Multiprobe studies on the corroded Bezinal sample surfaces prove the important role of Al in the corrosion mechanism. Fig. 13 gives a typical in-depth profile, showing the enrichment in Al in the outer zones (see also fig. 14). So, gradual passivation by Al-corrosion products (probably $Al(OH)_3$) is likely to be responsible for the outstanding corrosion resistance of these Zn/Al coatings.

3. Applications

The "Bezinal" coating not only outperforms considerably the zinc coating in corrosion protection, it is also superior in smoothness, adherence and formability, so that fatigue and corrosion fatigue properties are equally excellent.
At the interface between the steel substratum and the "Bezinal" coating, the mechanical properties of the alloy formation facilitate further deformation of the coated wires.
Applications of wire products, such as fencings, nettings, ropes and springs, in the agricultural, industrial, automotive, fishing, off-shore and construction business, can take full advantage of this new opportunity.

Some applications of Bezinal coated wire products have already confirmed, in real life condition, the favorable corrosion test results mentioned above.
As a matter of fact, this only applies for those wire products which are used in an extremely severe corrosion environment, such as :
seawater for fishing ropes
animal cultivation cages for nettings
chemicals for wire products in agriculture
(sprays : fungicides, herbicides, pesticides)
The pictures (fig. 15 and 16) illustrate the better corrosion protection for the Bezinal coated fishing ropes, compared to the double galvanized ones, after they had been exposed to seawater, as fishing ropes on the same boat.
In the case of the double galvanized rope wire, the corrosion attack seems to have penetrated to the steel substratum already.

For all the other products, applied in a less agressive environment, we will have to wait for facts and figures to confirm the advantageous use of the Bezinal coated wire and wire products, as reflected in the excellent comparative test results which we obtained in the accelerated tests.

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BEZINAL 1 versus GALVANIZED 1
in saltspray test

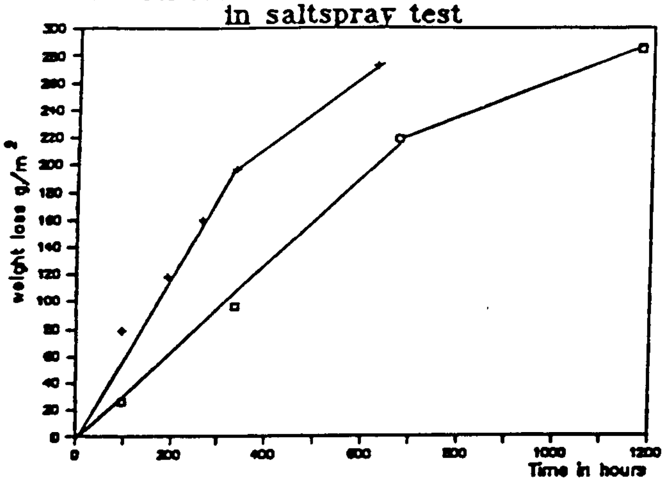


Fig 1

BEZINAL 3 versus GALVANIZED 3
in saltspray test

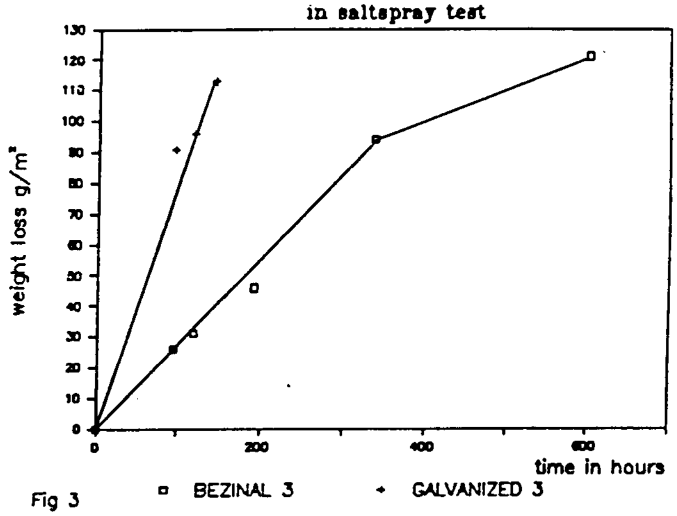


Fig 3

BEZINAL 2 versus GALVANIZED 2
in saltspray test

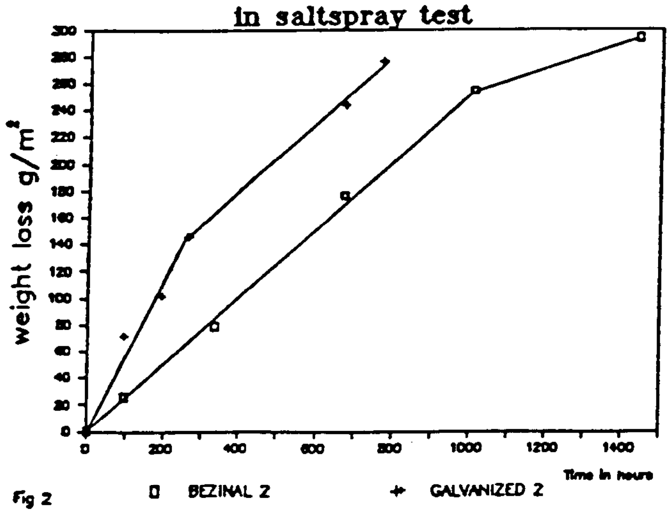


Fig 2

BEZINAL 1 versus GALVANIZED 1
in SO_2-test (1l SO_2)

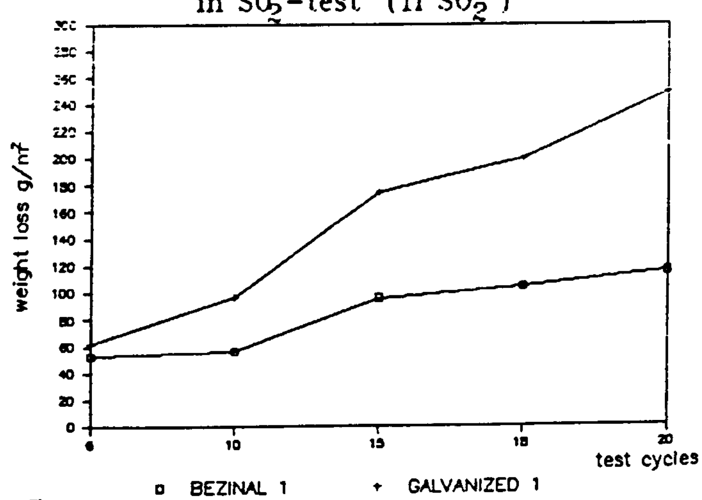


Fig 4

BEZINAL 2 versus GALVANIZED 2 in SO_2-test (1l SO_2)

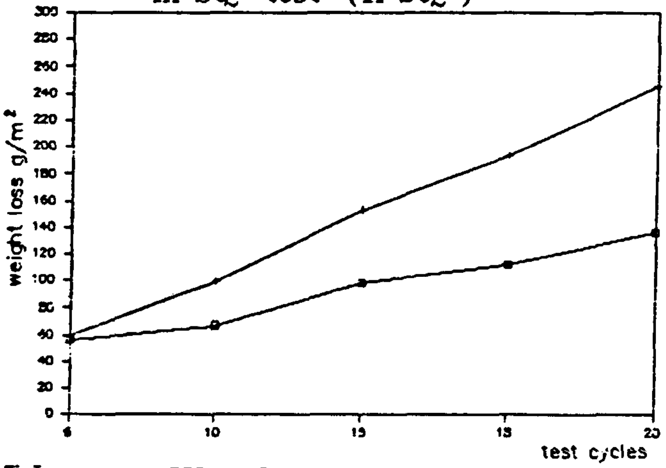


Fig5 □ BEZINAL 2 + GALVANIZED 2

Weight loss in mink food slurry, pH=6.9

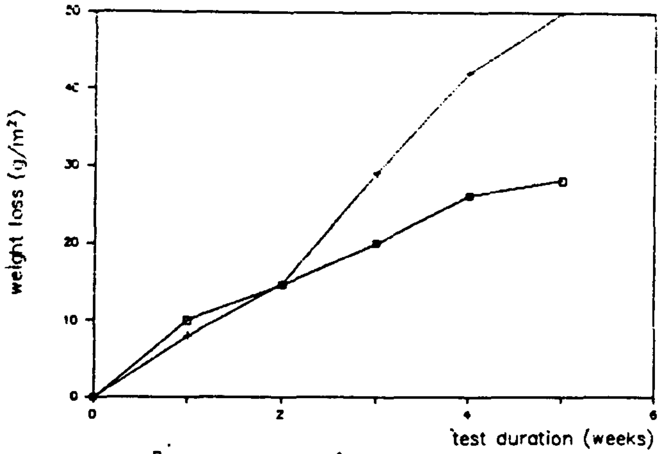


Fig8 □ BEZINAL + GALVANIZED

BEZINAL 3 versus GAVANIZED 3 in SO_2-test (1l SO_2)

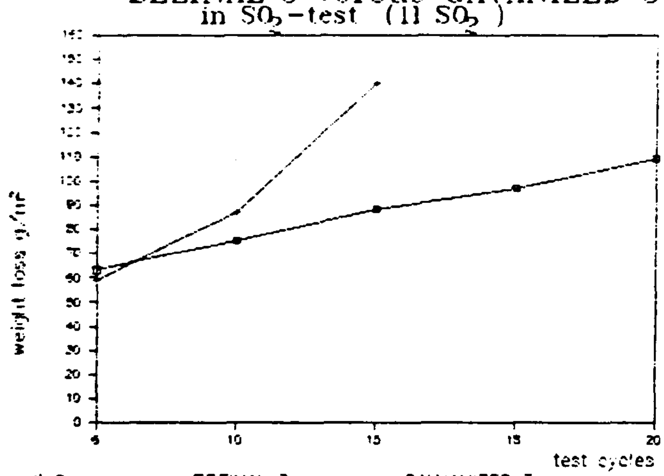
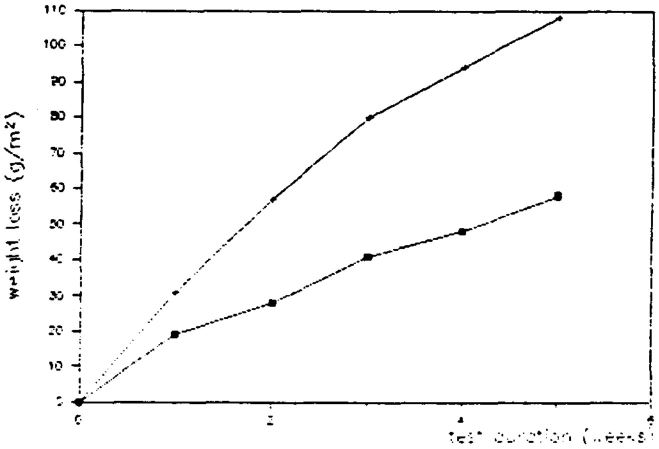


fig6 □ BEZINAL 3 + GALVANIZED 3

Weight loss in mink food slurry, pH=5



SO_2 test (1l SO_2) on welded nettings

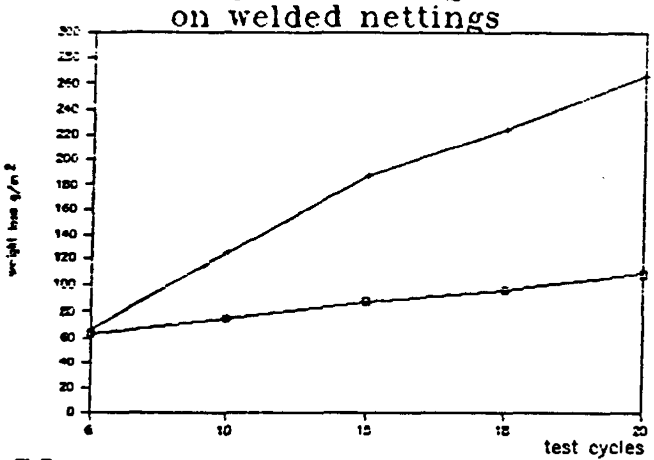


Fig7 □ BEZINAL + GALVANIZED

Binary phase diagram aluminum – zinc

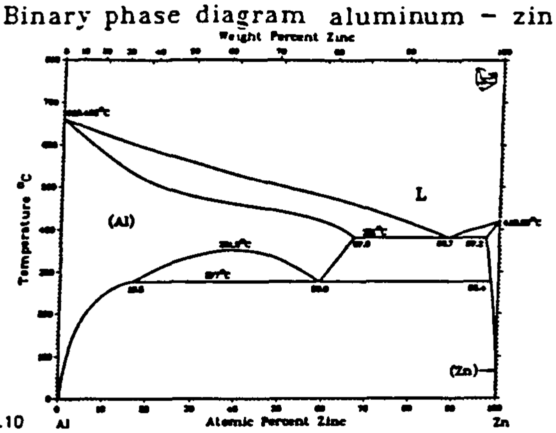
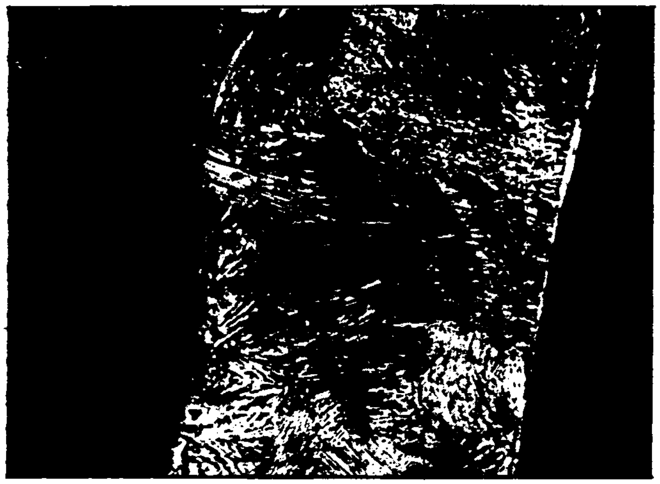
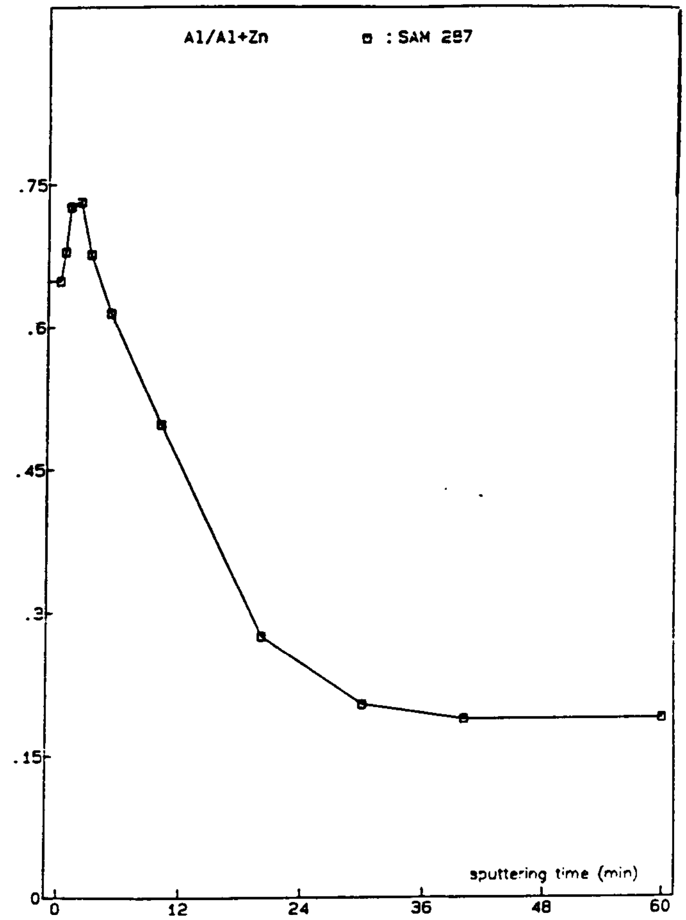


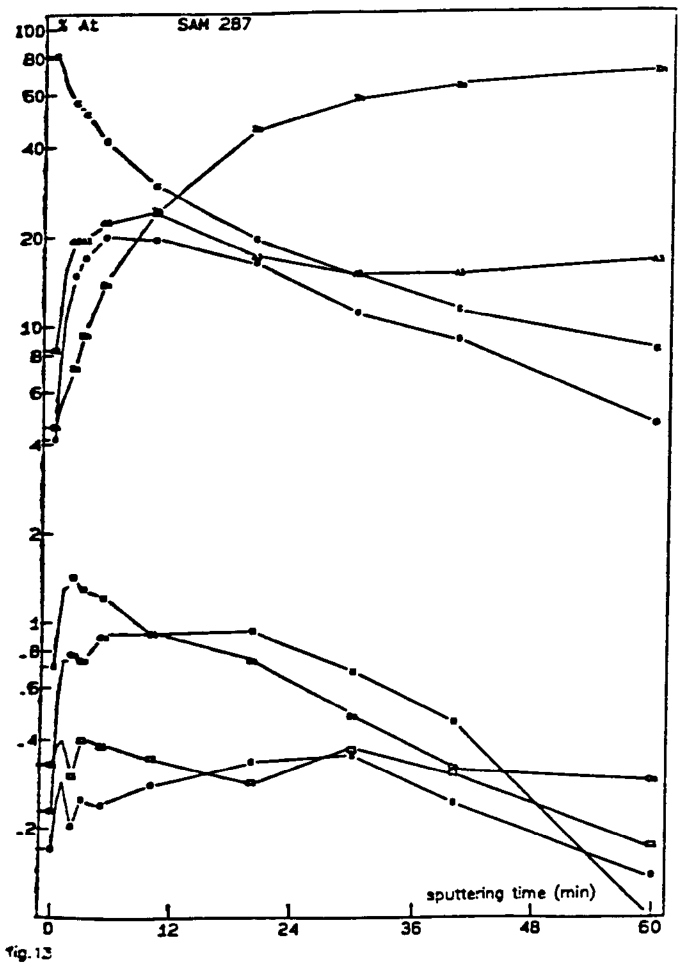
fig.10





Al/Al+Zn
□ : SAM 287
.75
.6
.45
.3
.15
0
0
12
24
36
48
60
sputtering time (min)

fig.14



100
% At
SAM 287
80
60
40
20
10
8
6
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1
.8
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sputtering time (min)
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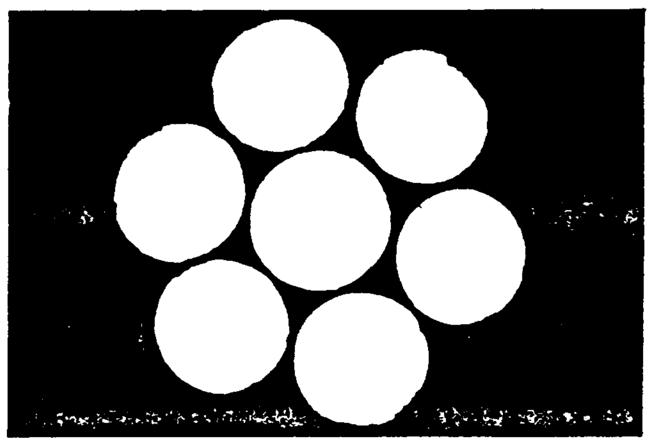
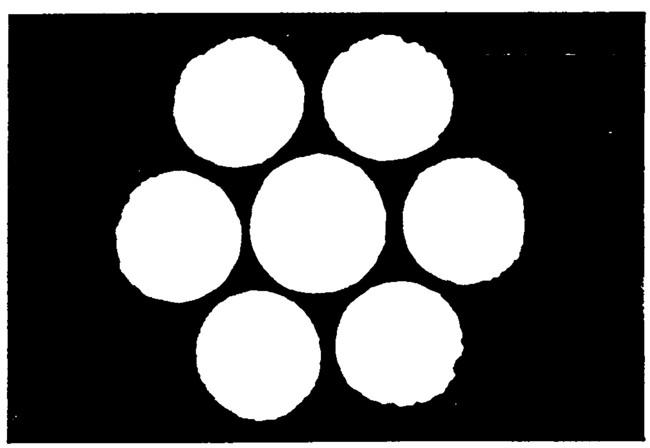
12
24
36
48
60

fig.13





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Practical Applications of Products Made from Galfan-Coated Wire:

State of the Art

(Referat on 5. June 1990 at ILZRO GALFAN LICENCEES MEETING 5 - 7 June 1990 in Liege)

1 Introduction

As I have pointed out in previous presentations and various publications, galfan coating offers increased corrosion protection. In addition, its characteristics are improved ductility, formability, better workability and coatability as well as a more favourable reaction to simultaneous mechanical strain and corrosion attack in comparison to zinc /2,3/, e.g. in the case of steel wire ropes. Our researches depend on products from ARBED Cologne and Luxembourg.

These advantages have been confirmed by other authors and are by now recognized as technical standard. Furthermore, the research which initially led to the findings mentioned here has been substantiated by further tests. As a result, galfan-coated wires have recently been used in a much wider variety of products. This is the basis of the findings I intend to talk about in this paper.

2 Vine-Yard-Wires

The first product to have been used extensively is vine-yard-wire. This low carbon galfan-coated steel wire has been subjected to the atmosphere for more than five years. Tests showed only an insignificant reduction of the protective coating. As expected, the wire kept its smooth layer, which prevents damage to the grapes.

3. Welded Fences

Over the past years, systematic tests have been carried out on welded joints of galfan-coated surfaces in comparison to zinc-coated welded fences. The results are conclusive: if the welding electrodes and the voltage are adjusted to the galfan-coated surface, a welded joint between such surfaces is possible and the positive anti-corrosion properties remain unchanged (figure 1).

As far as products of this type are concerned, the results indicate two distinct advantages of galfan in comparison to zinc, which have been confirmed by long-term practical applications.

Apart from the increased corrosion protection mentioned above, welded joints underline that galfan offers a better distant effect than zinc. At the weld the coating is usually damaged down to the steel core and remains active only at the edges. Galfan, however, offers improved corrosion protection at the weld.

The higher ductility of galfan in comparison to zinc-coated (i.e. piece-coated) fences has to be mentioned at this point. Consequently, cracking under mechanical strain is not to be expected. Furthermore, buckling - which is possible under the influence of the temperature of molten zinc - will not occur.

Therefore, the use of galfan-coated wire in the production of welded fences does lead to an extened service life, as the disadvantages of zinc-coatings, such as buckling and cracking, are no longer of significance.

Apart from short-term tests, investigations on cage fences have been conducted over a period of two years. The results confirm the improved anti-corrosion properties of galfan wires when compared with zinc-coated fences (figure 2).

4 Wire Fencing

As far as this line of products is concerned, it appears that galfan offers special advantages to field fence. Apart from the use of salt an increased density of traffic and the resulting SO2 attack have become more and more significant, particularly near motorways.

A five-year-guarantee cannot be achieved by the use of zinc-coated field fencing.

Tests on a motorway in the north of Germany over a period of four years showed extreme differences between galfan and zinc (figure 3).

5 Embankment Fortifications in Coastal Areas.

After approximately three years samples of galfan-coated and zinc-coated gabion wires were inspected. These are being used to fortify dykes in various coastal regions.

The supremacy of the galfan quality becomes obvious even by only visual inspection. It is confirmed by measuring the remaining thickness of the coating. In the case of galfan it remained on average at least twice as thick as with zinc-coated wires (figure 4 + 5).

6 Hooks used in Roofing

Hooks made from galfan-coated wires have in some areas become more common than hooks made from stainless steel or zinc-coated materials. As with other applications, their corrosion properties are excellent (figure 6 + 7).

Furthermore, these hooks offer improved mechanical characteristics, as galfan allows for multiple bending.

7 Cabels for Masts

The high quality of galfan coating has led to increasing acceptance in the production of strands.

The advantages concerning service life allow for longer intervals between rope changes, which reduces the cost of labour quite significantly.

Initially, spiral wire ropes were used, e.g. with eleven transmission masts for Danish television.

In the meantime, we are successfull in producing profil-wires for cabels (S-Profil) Therefore, now even wire ropes with closed surfaces are being used, e.g. Hessischer Rundfunk and Radio Free Europe. Most German TV stations have expressed their intention to switch to galfan quality.

8 Cables for running purposes

8.1 Wire Ropes in the Fishing Industry

Reports on the use of galfan-coated wire ropes in the fishing industry have been presented repeatedly. The improved anti-corrosion protection offered by galfan particularly in sea water led to an increased demand in this sector.

8.2 Mining Ropes

Improvements in the construction of mining ropes have led to increased service life. As a result, 50% of the ropes are currently being cast off not for reasons of mechanical wear but because of corrosion damage.

The quality of galfan coating is suited to prevent such damage, as its improved corrosion properties are beyond doubt. The mechanical and technological characteristics of galfan-coated steel wire and wire ropes in comparison to zinc-coated materials have recently been investigated. (Doctoral thesis Sczepanski)

The results of these investigations into the mechanical and technological characteristics of the wires are shown in the following bar-chart. Each bar shows the comparison between the specimen in percent.

As far as tensile strength Rm, 0.2% proofstress Rp 0.2 and the bending and torsion count are concerned, the galfan coated samples show similar characteristics to the finally galvanized wires. However, they show an advantage of approximately 5 % and even 10 % with regard to the torsion count. The zinc-coated redrawn specimen surpasses galfan by approximately 5 - 10 % only as far as tensile strength, 0.2 % proofstress and bending count are concerned. With regard to ductile yield, elongation limit relation and torsion count the galfan-coated wire shows the best results.

Further tests (Tension-Tension-Fatique-Test and Torsion-Bending-Test) were carried out to determine the mechanical (dynamic) characteristic values:

The diagram indicates that all dynamic characteristic values of the galfan samples show better values than those of the zinc-coated specimen (approximately 10 - 30 %). The properties of the coating already mentioned above are confirmed in their positive effects when subjected to long-term tests. The fact that the test results show that in some cases galfan coated wires even surpass non-zinc-coated wires can be attributed to the corrosion attack on the blank, non-protected material. This fact stresses the need for corrosion protection in wires. Even though characteristic values are neglected when judging wires according to standards, these are of extreme importance for the characteristics of wire in practical applications. Therefore, the positive results of the investigation of galfan-coated samples with regard to this aspect have to be emphasized at this point in addition to the positive static and technological characteristic values (figure 8).

Following the positive results of the investigation described above (results of tests on wire, flexural-type tests with strands and ropes), it was decided to install a mining rope made from galfan-coated wires in a pit of the Bergwerk Westerholt. The project is being conducted in co-operation with the WBK-rope testing laboratory and the Ruhrkohle AG. The rope tested is a Koepe-Mining Rope with the hoisting machine installed in the upper part of the pit (system Berghoff; figure 9).
With regard to mechanical wear as well as corrosion attack this pit puts a lot of strain on the mining ropes in use.

This is confirmed by comparisons between pieces of rope and de-zinced wires of these ropes in traditional zinc-coated and galfan-coated specimen after one year of use in the pit. During the investigation the rope is checked regularly together with an expert from the WBK rope testing laboratory.

Test Results

The ten ropes which had been used prior to our investigation had to be changed after between five to thirteen months. A Rope made from galfan-coated wires, however, has to date shown a service life of 24 months.
The groce output with the use of this rope is approximately 1500 MNn/kg at 70 haulings per day on average. This exceeds the capacity of the ropes made from zinc-coated wires used previously, which averaged an output of only between 500-1000 MNn/kg.

The results show quite clearly that the use of galfan-coated wires even under extreme mechanical strain and simultaneous corrosion attack does not lead to premature rope failure. On the contrary, its positive effects, such as ductility and lubricating action, in comparison with common zinc-coating show distinct advantages /4/.

The positive results of laboratory tests on samples made from galfan-coated wires were confirmed by the on-site tests.

Let me first show you the coatings in unused samples in a longitudinal section. The iron-zinc-alloy and the pure zinc layer can be seen quite clearly in the picture at the top showing a finally galvanized specimen. The bottom picture shows the layers on the redrawn samples. The iron-zinc-alloy has been damaged by redrawing (figure 10).

Where galfan coating is concerned, the alloy layer is very much thinner and only just visible in its lower part on the steel.
A large quantity of galfan can be seen on the surface.

If these coatings are subjected to drawing or lateral power, the final coating shows the formation of cracks in the iron-zinc-alloy, known to be brittle, which are covered by the pure zinc layer. So called blocks are formed under severe stress, which remain firmly connected to the steel and, therefore, do not allow for further extension. The steel can only extend further in the areas between the blocks. The fact that these are the parts where the total extension must take place quickly leads to overstraining and the start of cracking (figure 11).
The redrawn zinc-coating quickly forms cracks in the iron-zinc alloy under strain, as it is no longer compact but has been damaged by the drawing process. However, because of this it is capable of an even extension, so that the wire breaks at the weakest point. In general, these weak spots result from damage to the surface by pieces of hard zinc which, in turn, result from redrawing.

In the case of galfan, such cracks only occur under more extreme stress than with zinc-coating.

However, galfan also shows large and wide cracks under extreme stress, which lead to overstraining in parts of the steel.

Therefore, its breaking mechanism show the same characteristics as that of the finally galvanized samples, but cracks in the coating only occur under more severe stress. This effect can be attributed to the greater flexibility of galfan or the layer of the galfan alloy when compared with the brittle iron-zinc-alloy.

Investigations into the Hardness

The next step in our line tests was an investigation of the hardness and the abrasion and friction properties of the coatings.

As far as measuring the hardness is concerned, we were able to establish the following figures concerning the average hardness of the coatings on steel wire with a diameter of 7 mm.

Zinc-coating:

Pure zinc layer (Eta)	35 HV 0.01
Iron-zinc-alloy (Delta)	93 HV 0.01

Galfan coating:

Galfan	51 HV 0.01
transformed Fe/Zn alloy	62 HV 0.01

These figures underline quite clearly that both coatings show differences in their hardness (figure 12).

If one sets the value of the average hardness of iron-zinc-alloy 3/3, the corresponding figure for galfan can be set at 2/3 and the figure relating to pure zinc at approximately 1/3.

This means that the zinc layer shows a clear jump of approximately 60 degrees of hardness between iron-zinc-alloy and pure zinc. This must be seen in contrast to the relatively continuous scale of hardness of the galfan layer.

However, the pure zinc layer with its lower hardness does not offer better protection under mechanical strain on a zinc-coated surface, so that the iron-zinc-alloy is directly affected. As this layer is relatively brittle it cannot compensate severe stress by ductility. This may lead to cracking in the protective layer which then leads to partial strain on the steel.

Even though the hardness of galfan is approximately 30 degrees lower, the layer is more uniform. As a result, a fine uniform layer with high ductility conteracts against external mechanical strain. For example: wires from the outer layer from a rope after working (figure 13).
An influence of different times set for cooling and running speed on the hardness of the galfan coating was not detected.

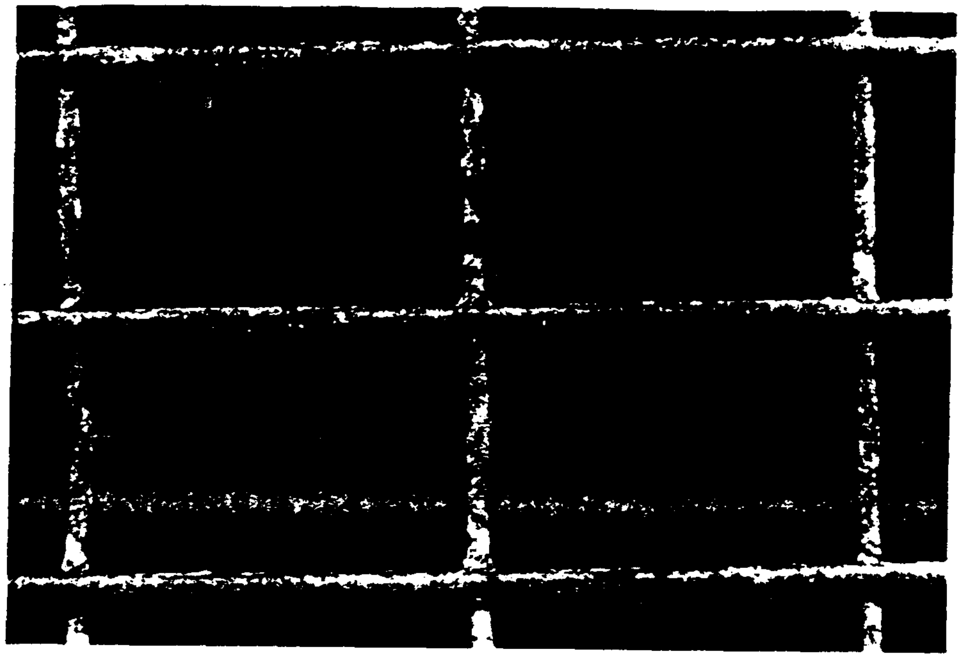
Abrasion and Friction

The abrasion was measured with the aid of a Taber Abraser. No significant differences bwtween zinc and galfan were determined. The average abrasion index numbers established differed by less than 0.01 mg/rotation.
The friction of the ropes made from galfan-coated and zinc-coated wires mentioned above was measured in a lubricated and non-lubricated state on a trial station for friction testing at the WBK rope testing laboratory in Bochum.
The tests indicated that a galfan coating results in a slightly higher friction increased by a maximum of 5/100 when compared with finally galvanized or redrawn coatings. This increase is not significant. Therefore, no differences in slippage have to be expected when using ropes made from galfan-coated wires.

9 Prospects

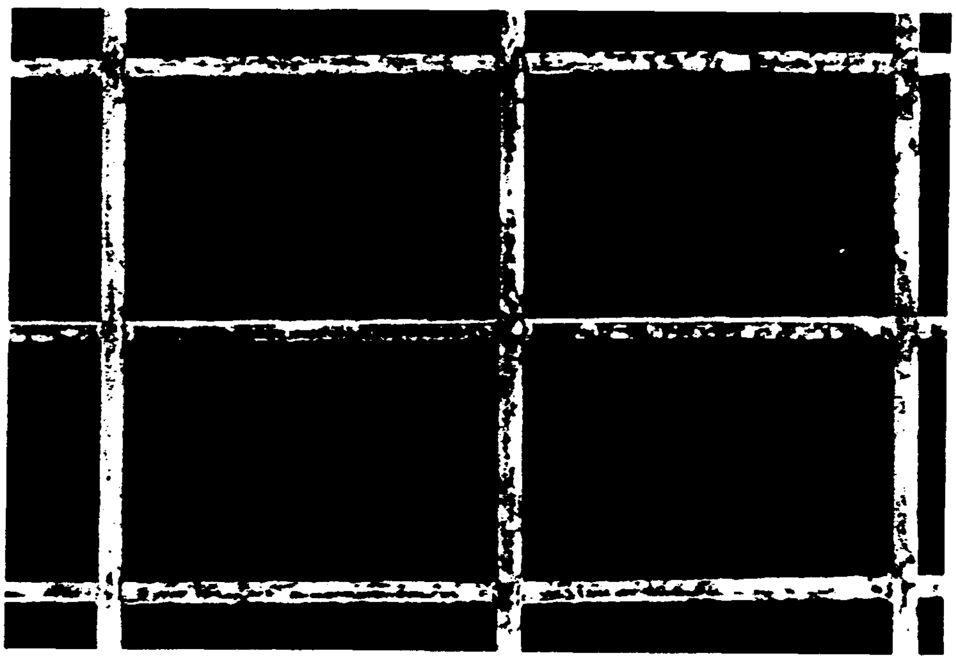
As I already mentioned in Helsinki in 1989, attempts are currently being made to transfer the galfan process to piece-coating in order to introduce piece-galfan-coating. At the moment, we are conducting laboratory tests and investigations into production processes.

Initial results will be published shortly.



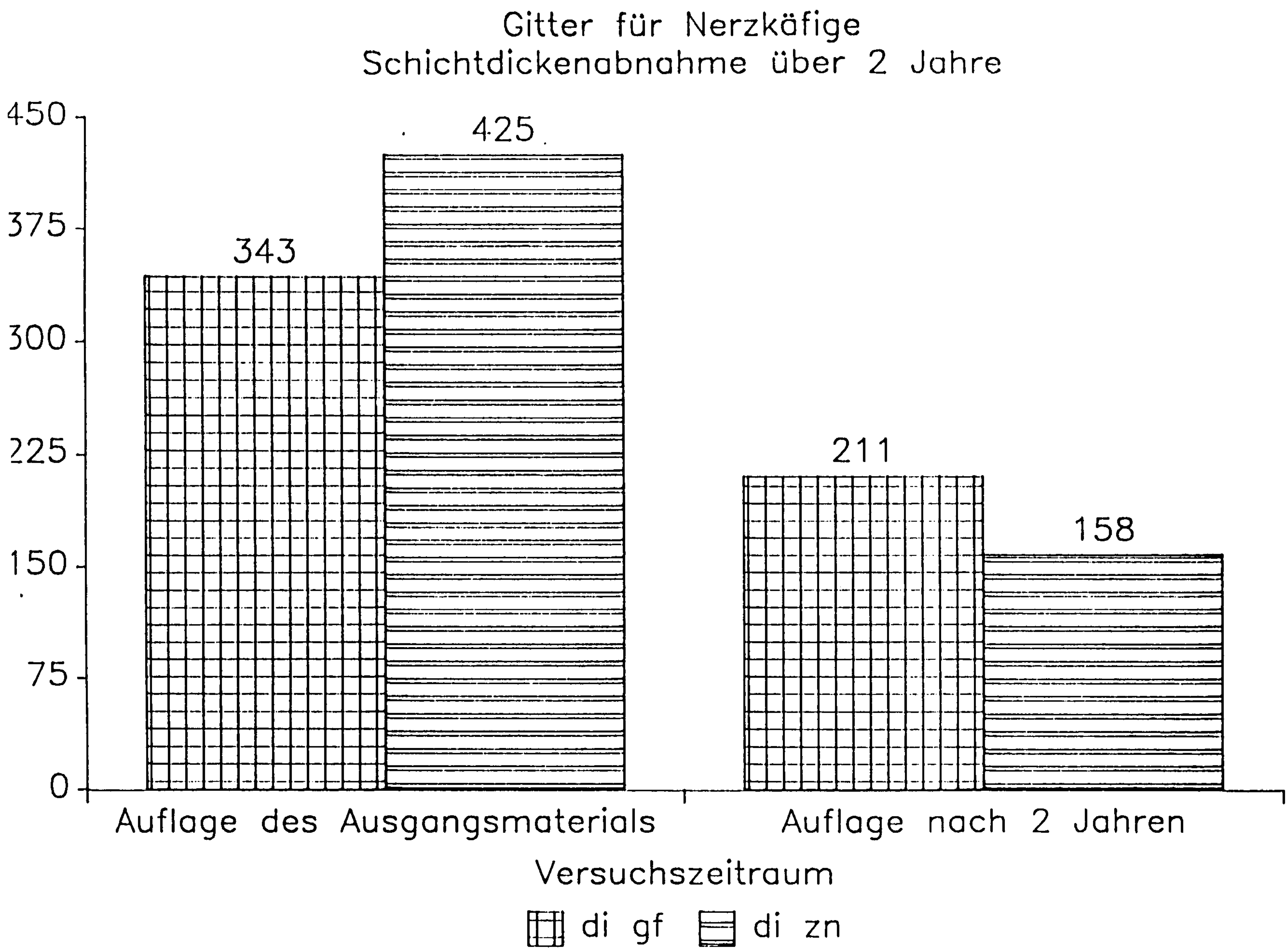
35. Zyklus

Gitter stückverzinkt, Maschenweite 25 x 40 mm



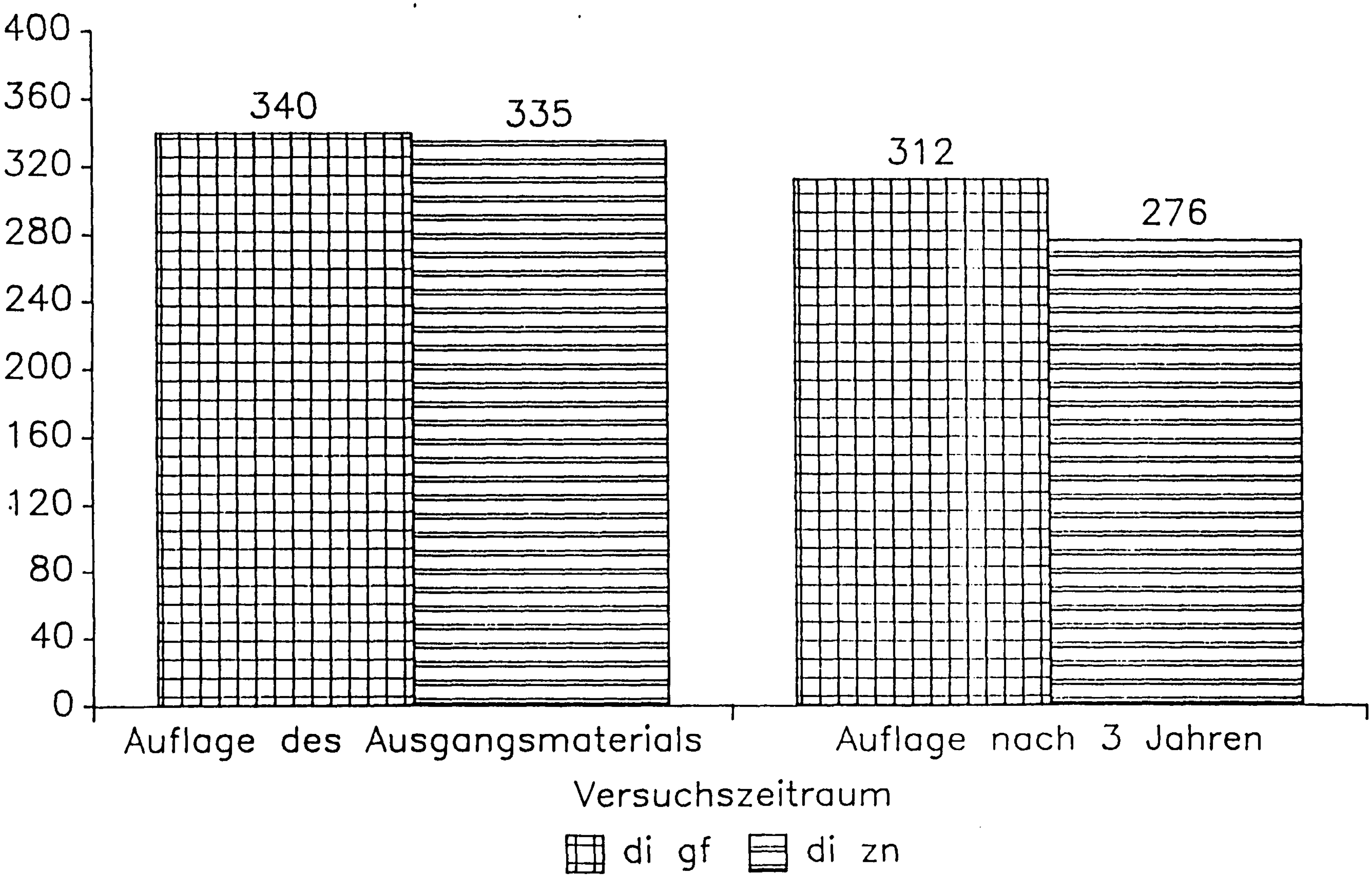
35. Zyklus

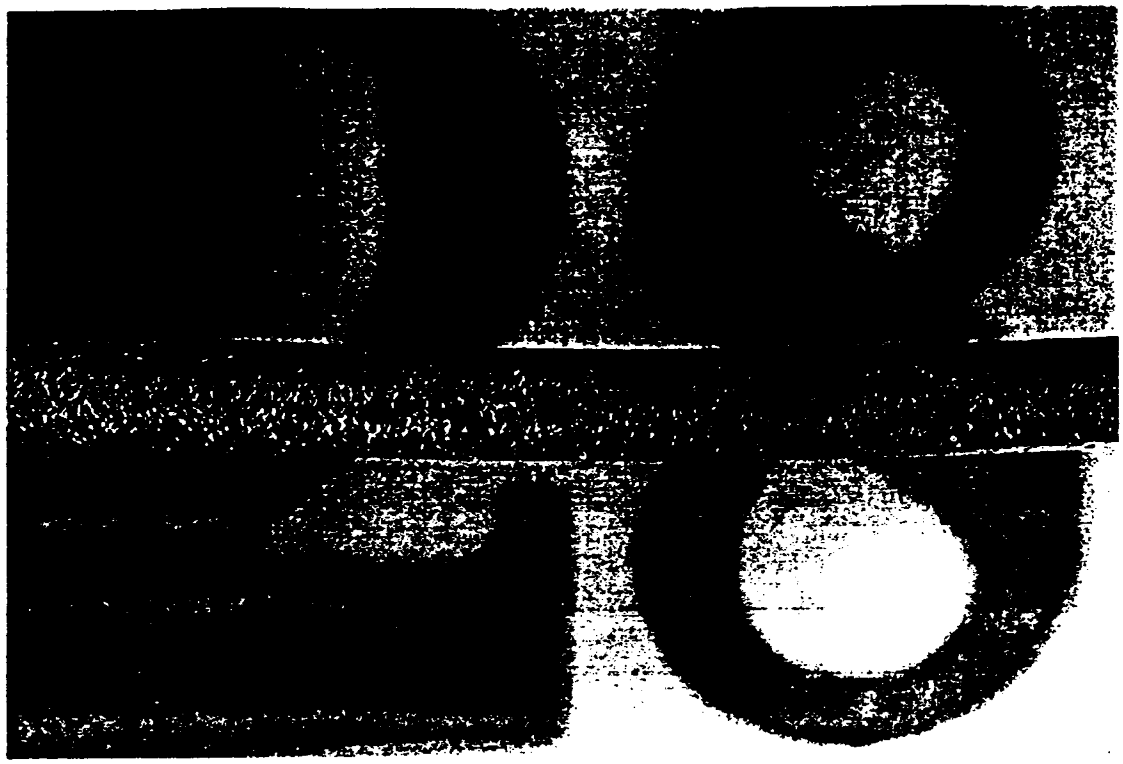
Gitter galfaniert, Maschenweite 25 x 40 mm


Gitter für Nerzkäfige
Schichtdickenabnahme über 2 Jahre
450
375
300
225
150
75
0
425
343
211
158
Auflage des Ausgangsmaterials
Auflage nach 2 Jahren
Versuchszeitraum
di gf
di zn

2

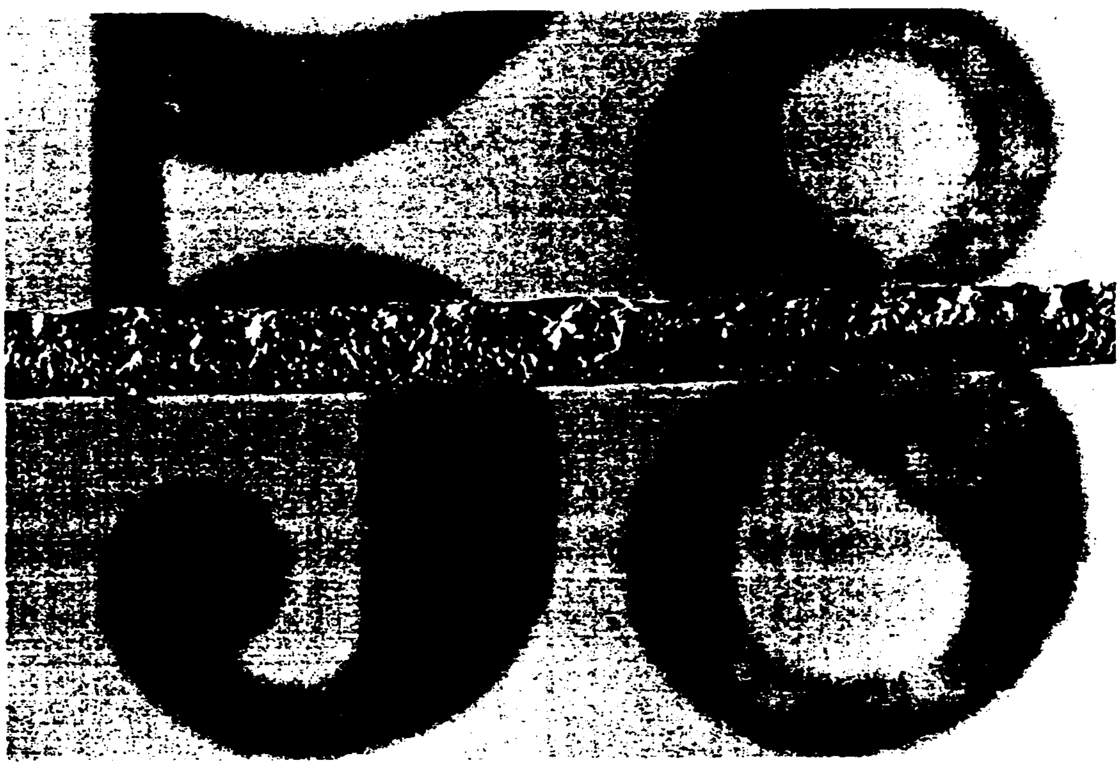
Knotengeflecht 3,0/2,5 mm Durchmesser
Einsatz im Küstenbereich
Schichtdickenabnahme über 3 Jahre





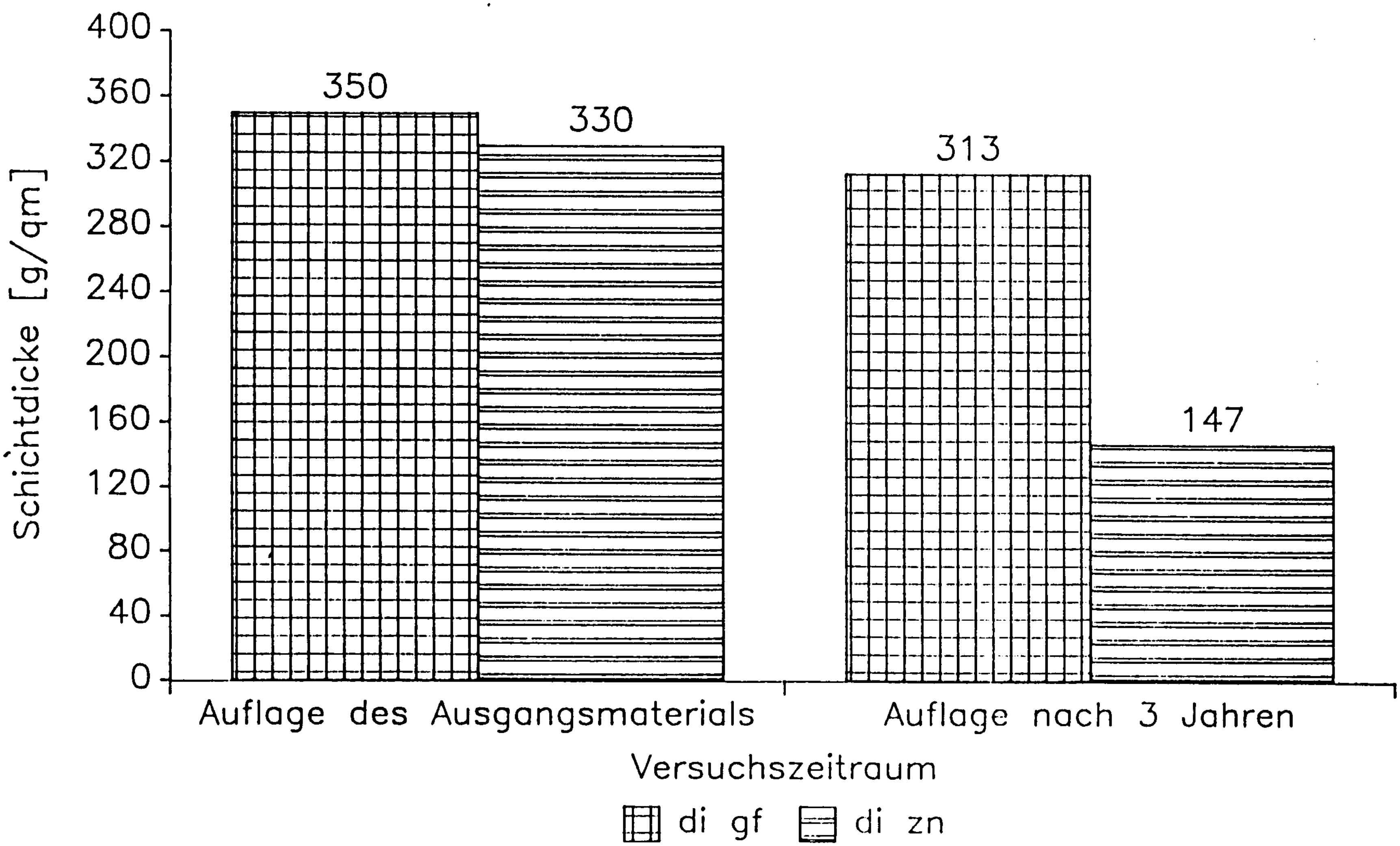
Spanndraht galfaniert

Einsatz über 3 Jahre im Küstenbereich



Spanndraht dickverzinkt

Spanndraht 3,0 mm Durchmesser
Einsatz im Küstenbereich
Schichtdickenabnahme über 3 Jahre



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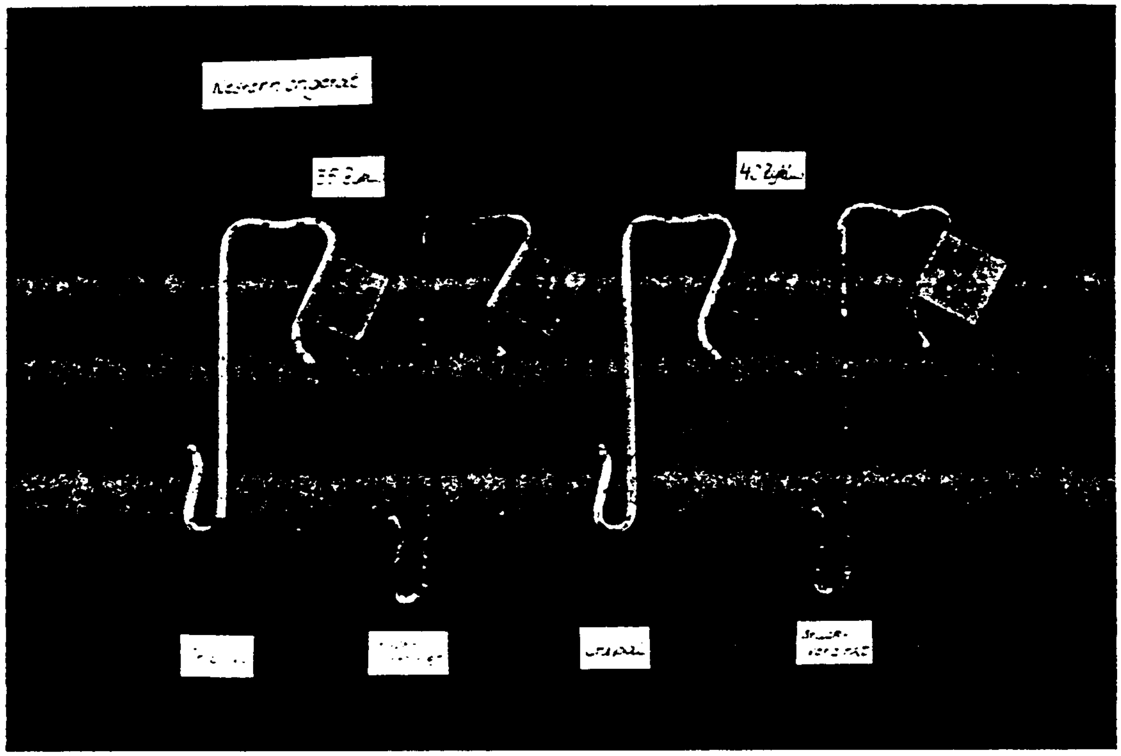
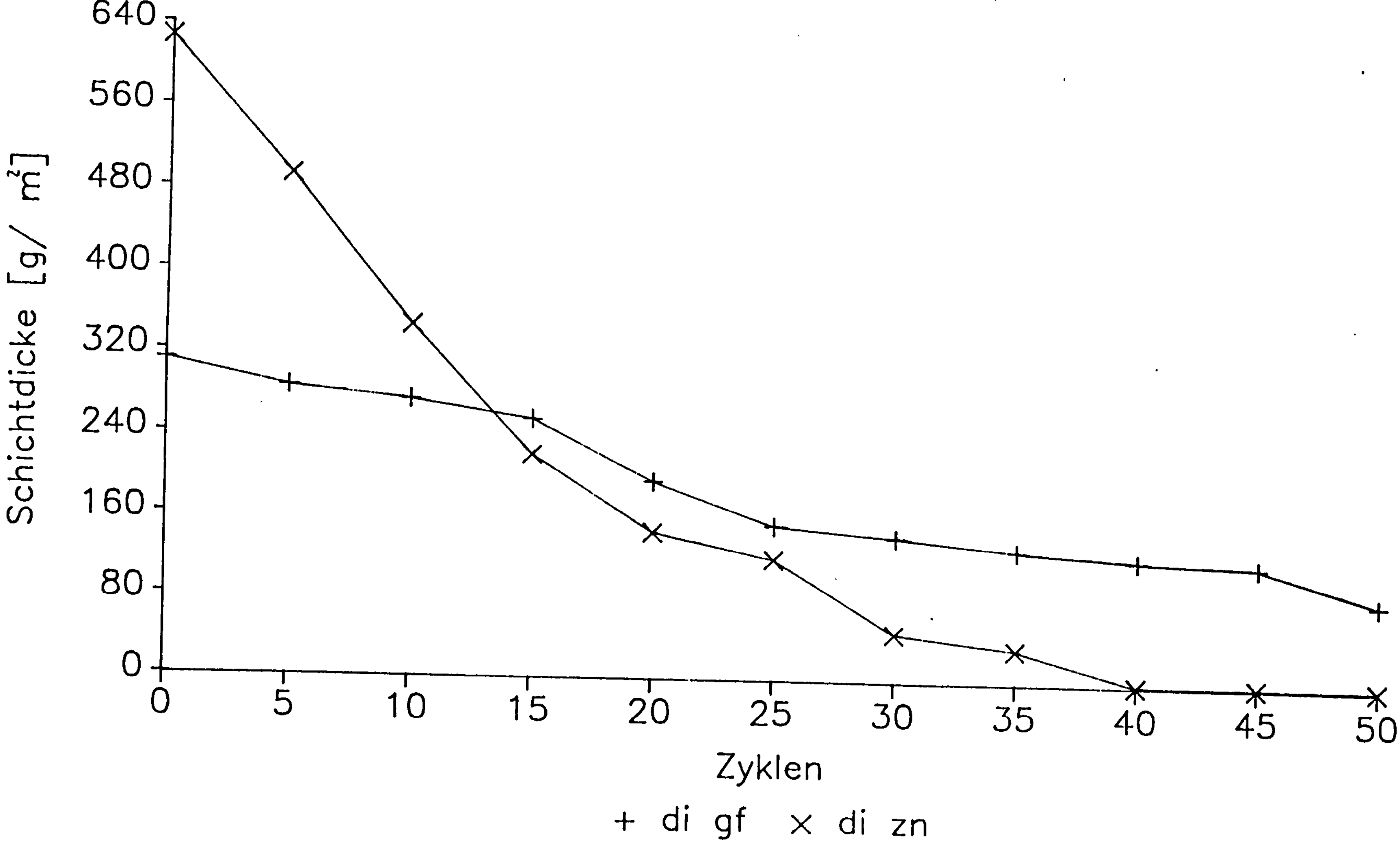
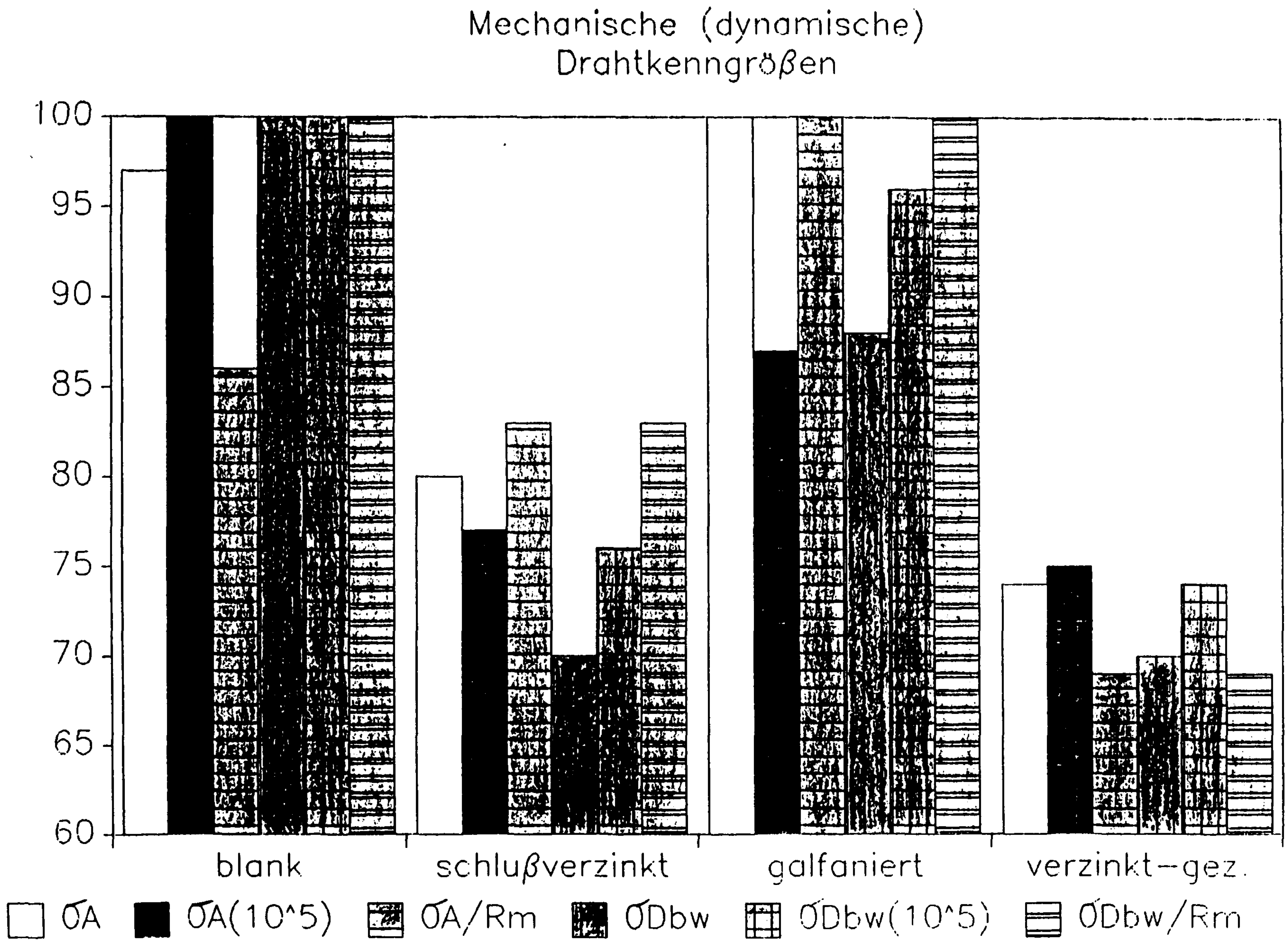


Dachhaken stückverzinkt und galfaniert

nach 35 und 40 Zyklen in schwefeldioxidhaltiger Atmosphäre

Dachhaken
Schichtdickenabnahme in
Schwefeldioxidhaltiger Atmosphäre

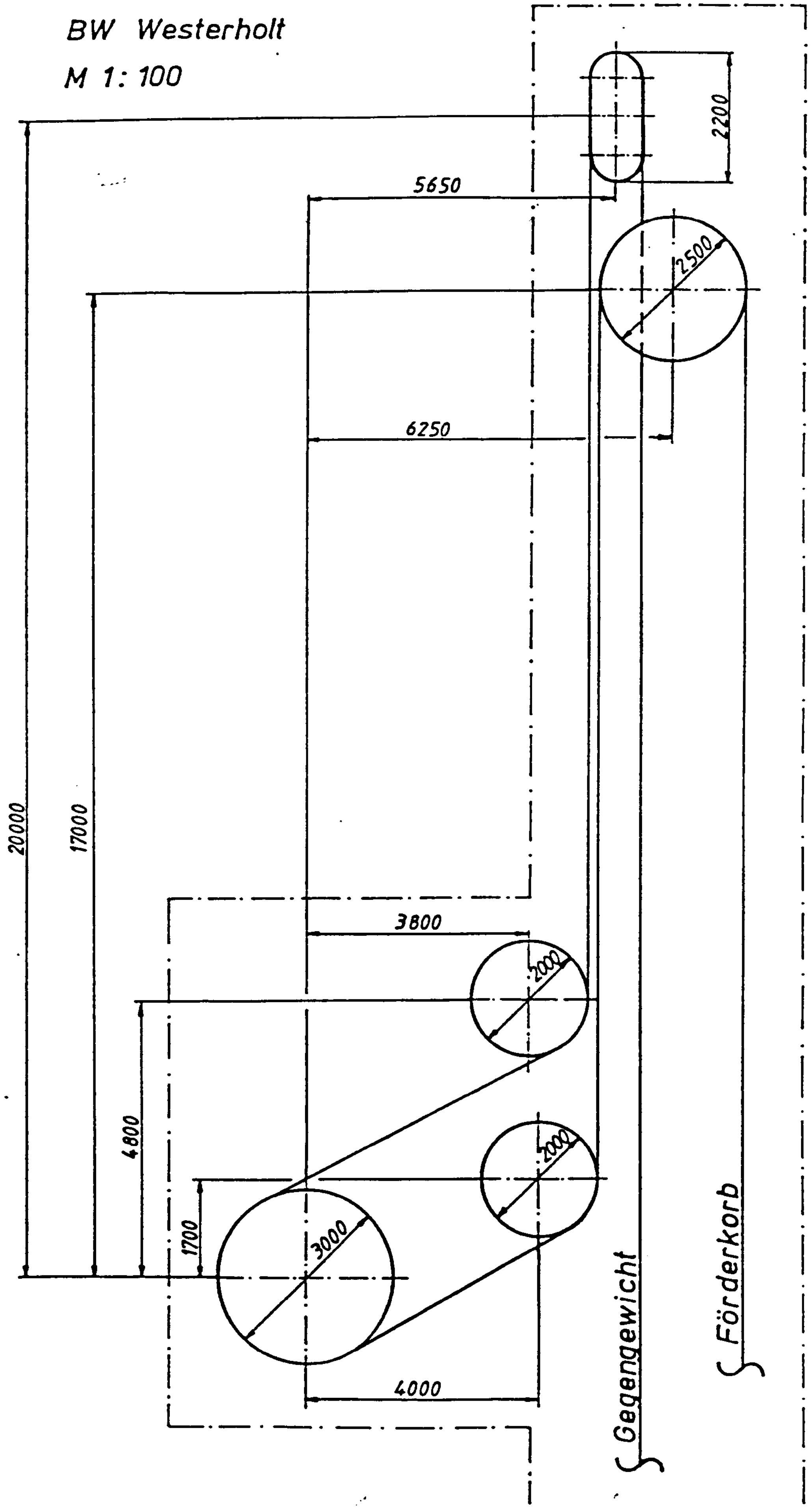


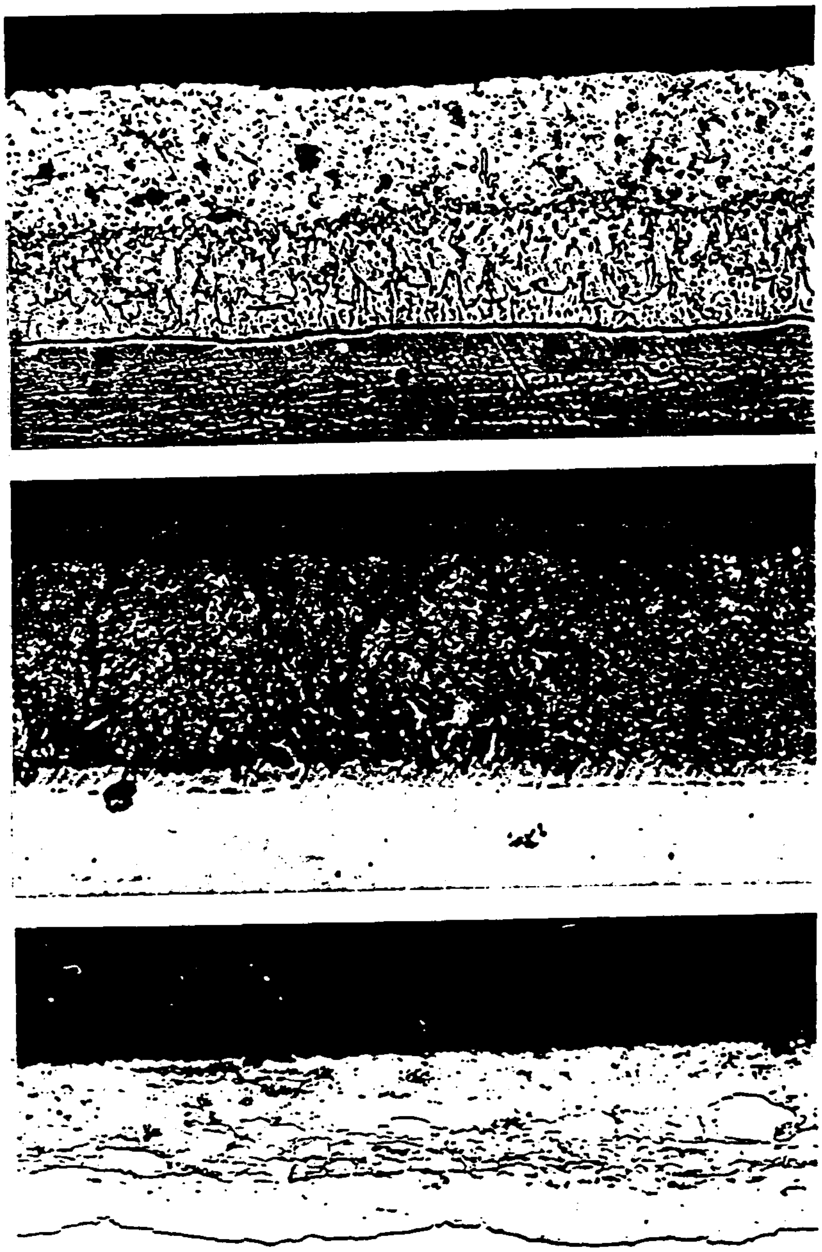

Mechanische (dynamische)
Drahtkenngrößen
100
95
90
85
80
75
70
65
60
blank
schlußverzinkt
galfaniert
verzinkt-gez.
σA
σA(10^5)
σA/Rm
σDbw
σDbw(10^5)
σDbw/Rm

Blindschacht

BW Westerholt

M 1: 100





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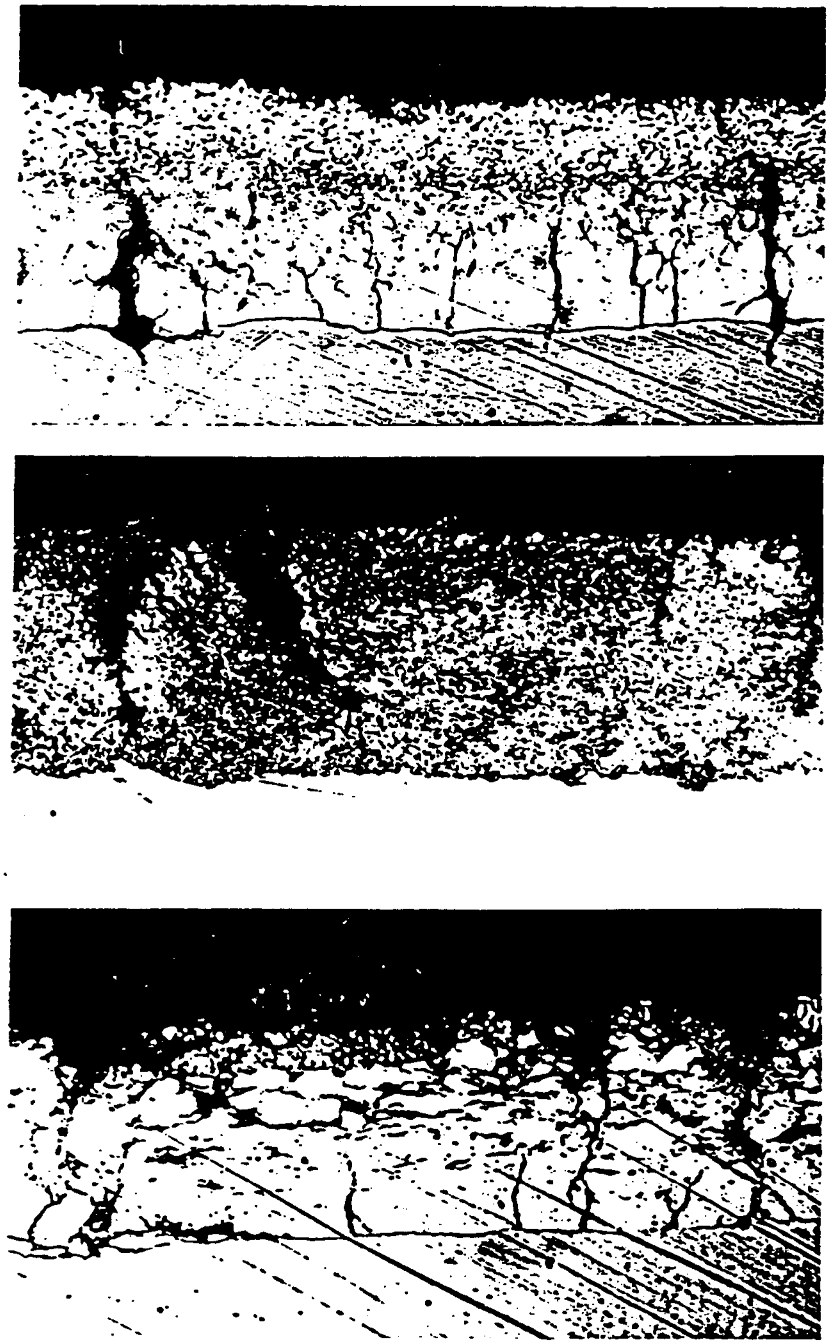

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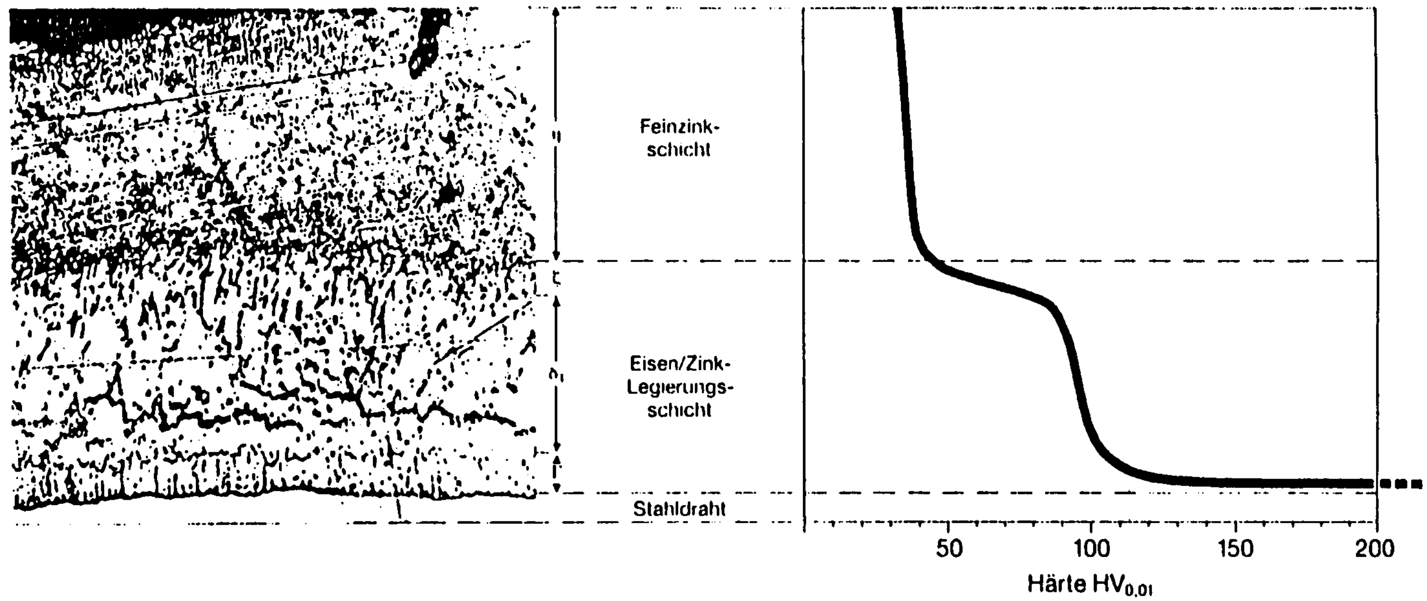
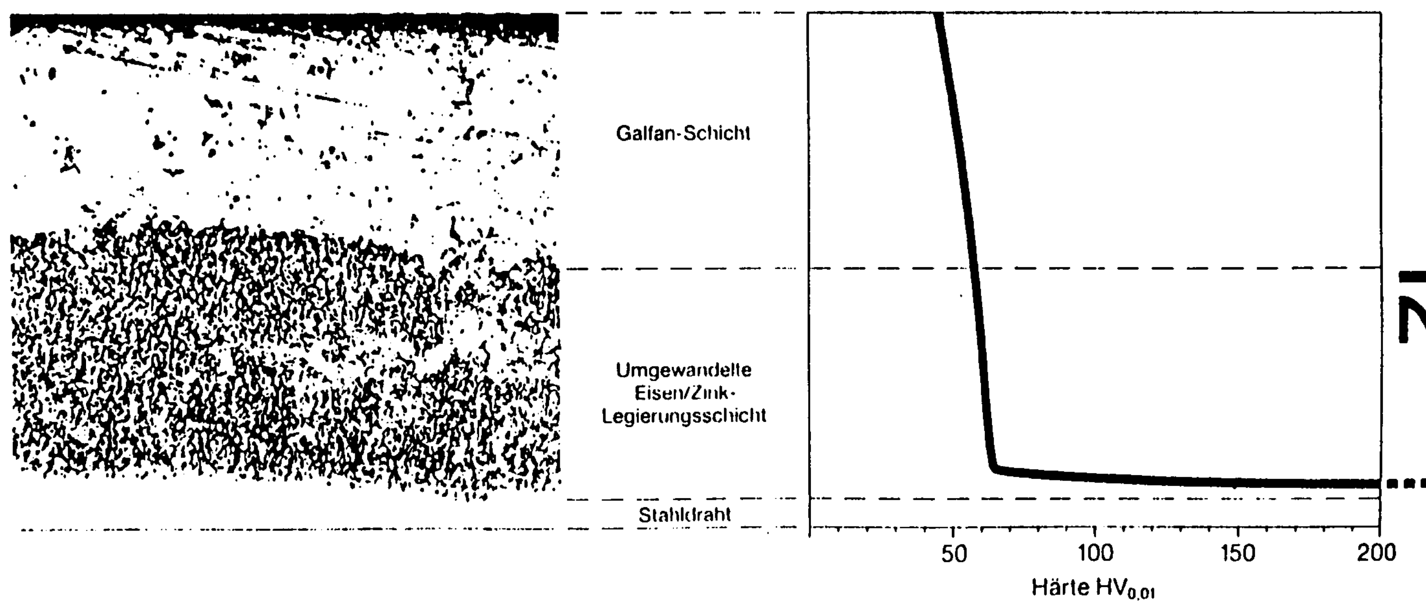
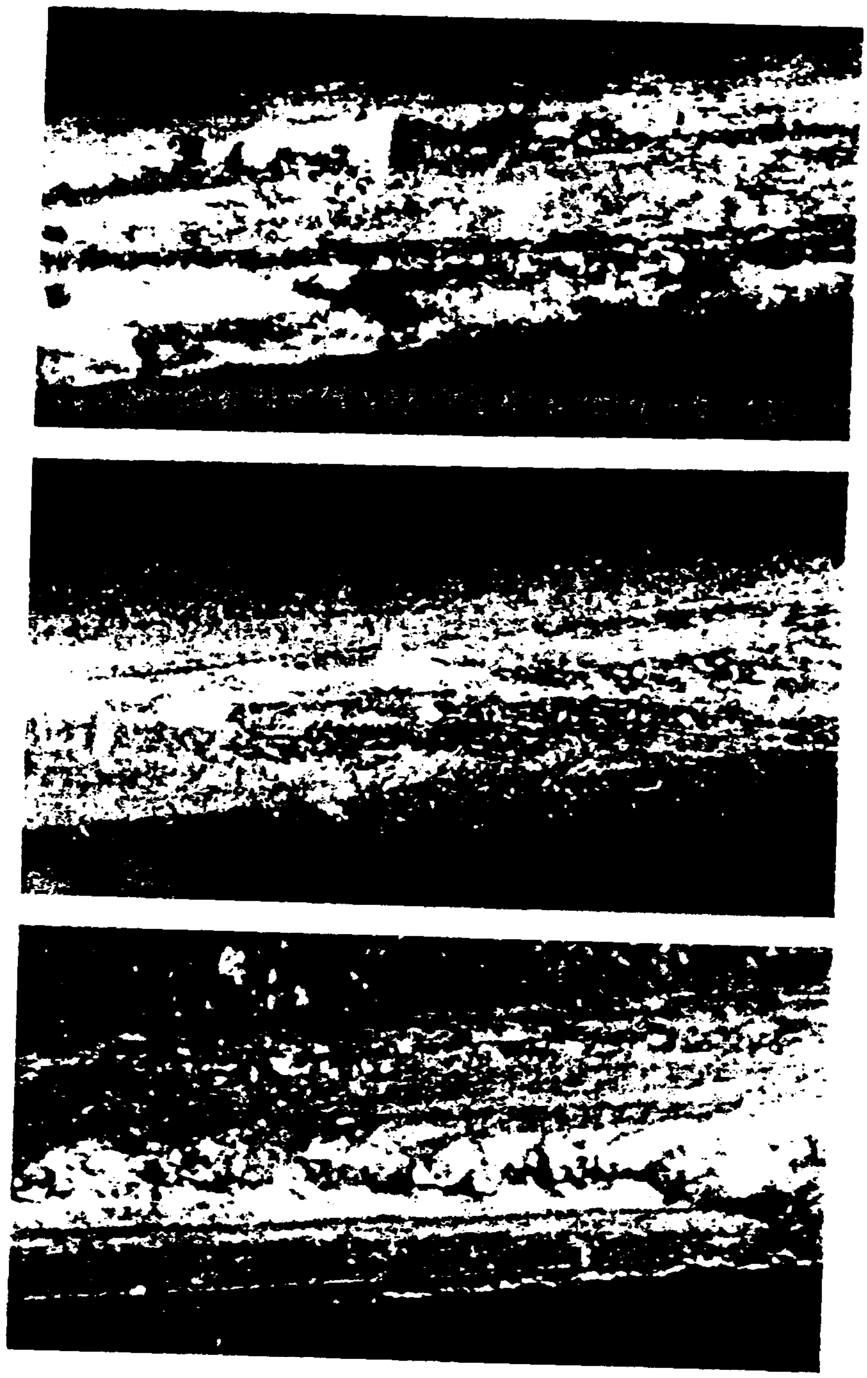


Härteverlauf in einem Zinküberzug eines Stahldrahtes von 7 mm ø



Härteverlauf in einem Galfanüberzug eines Stahldrahtes von 7 mm ø



Verschleißstellen (Außenlage) nach der Biegwechselbeanspruchung - schlußverzinkt (oben), galfaniert (mittig) und verzinkt-gezogen (unten) x 18

HOESCH STAHL AG
Wolfgang Schwarz
05.06.1990

Corrosion resistance of Galfan in NaOH-, NaCl- and SO_2-Solutions

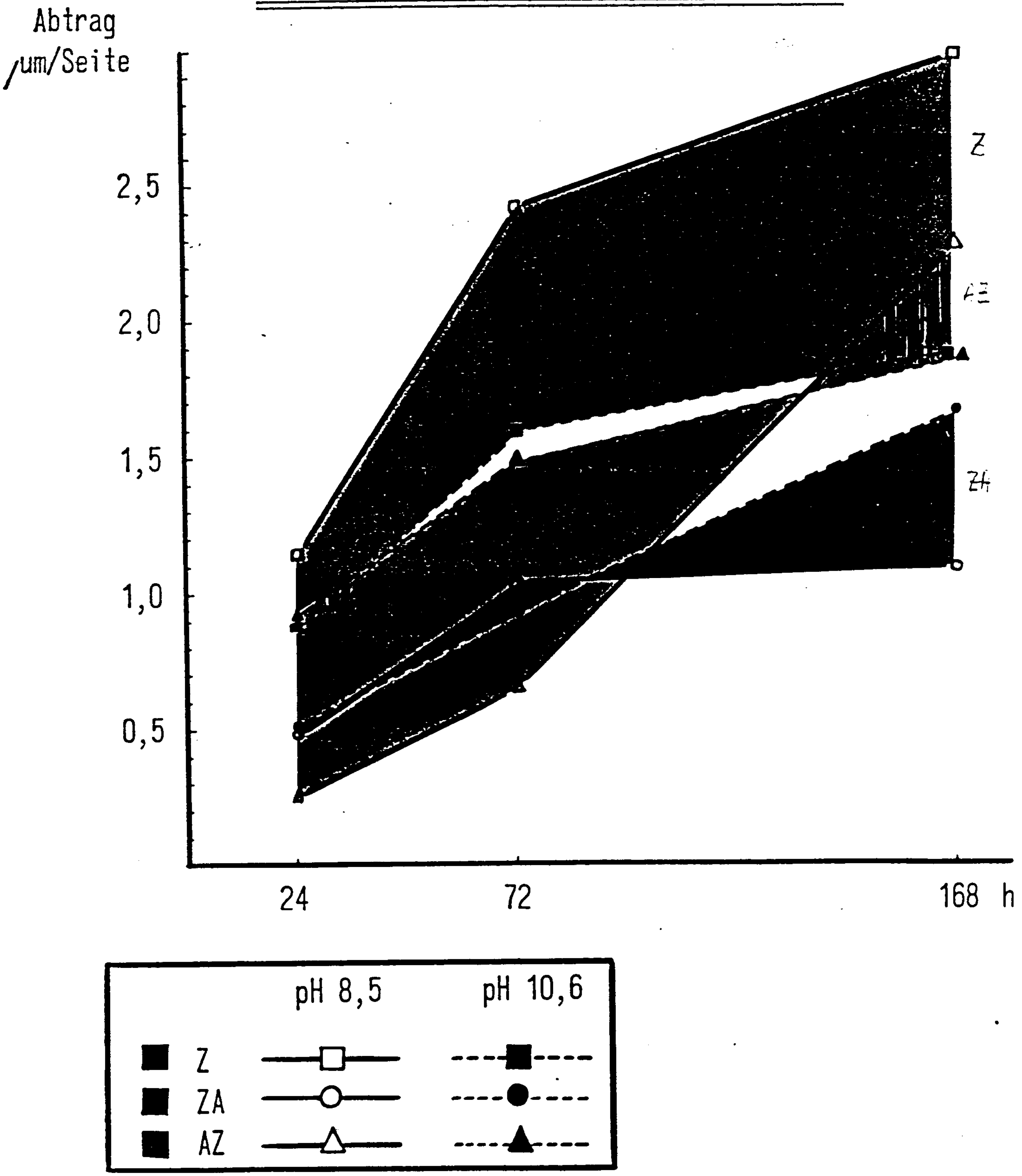
Because often there are questions for the corrosion behaviour in alcalyne medias, we have tested Galfan, HDG and Galvalume at p_H-values of 8.5 and 10.6 within short times up to 168 hrs. NaOH-solution was kept under N_2-atmosphere to maintain constant p_H-values. 70 x 50 mm^2 test pieces have been weighted before testing and lateron after rinsing in 5 % acetic acid, brushing, rinsing in water and drying. After 7 times weighing the average value of weight loss of the last 4 times was taken for the result. Fig. 1 shows these results dependent of the time of testing.

Galfan has a better corrosion resistance at p_H-values of 8.5 and 10.6 after 168 hrs testing than HDG and Galvalume.

Furthermore corrosion behaviour of Galfan and HDG again was tested in short time tests under NaCl- and SO_2-solutions according the standards of DIN 50 021 / ASTM B 117 and DIN 5o 018 SFW 2.0 S (20 ppm SO_2). Fig. 2 and 3 demonstrate the better corrosion resistance of Galfan in these environments.

Valuing these tests we have to consider, that the treatment has been very short in severe aggressive environments, and that conclusions on the behaviour for long times only conditional are allowed.

Massenverlust nach "Kochtest" (95± 2 °C)



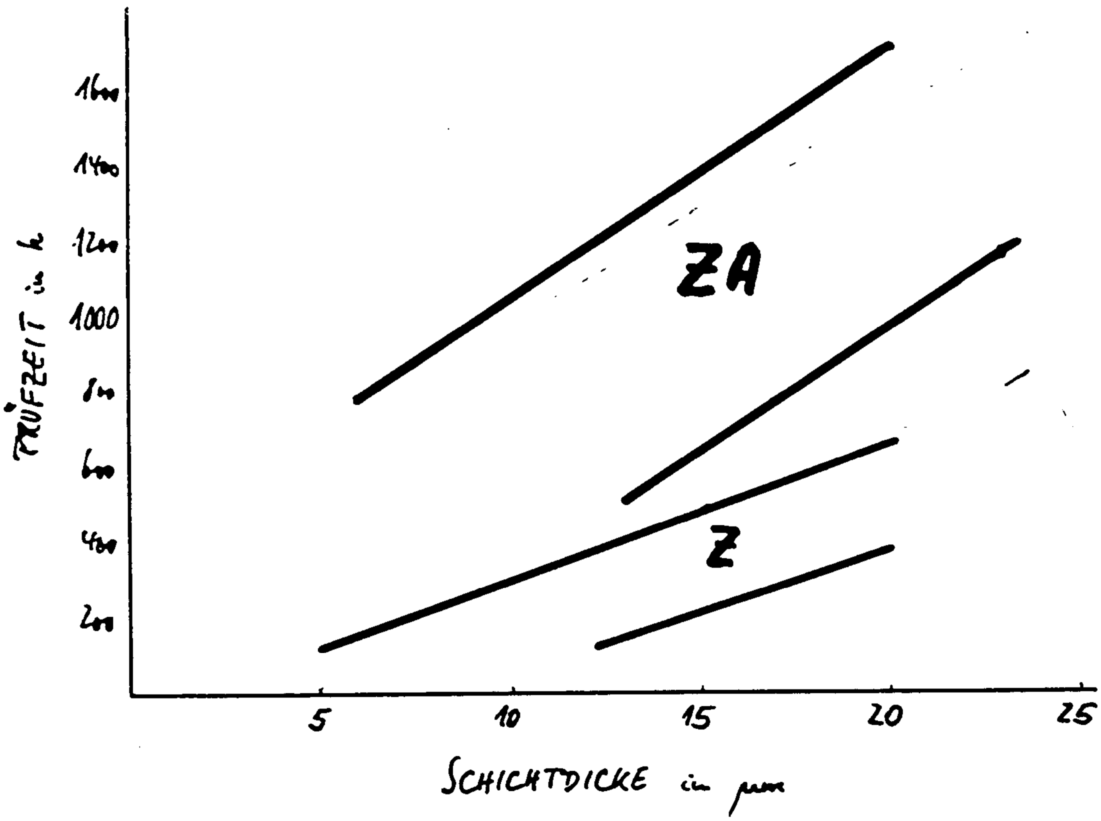


Bild 5: Rotrostbeginn $R_i = 1$ im Salzsprühnebeltest (5% NaCl)

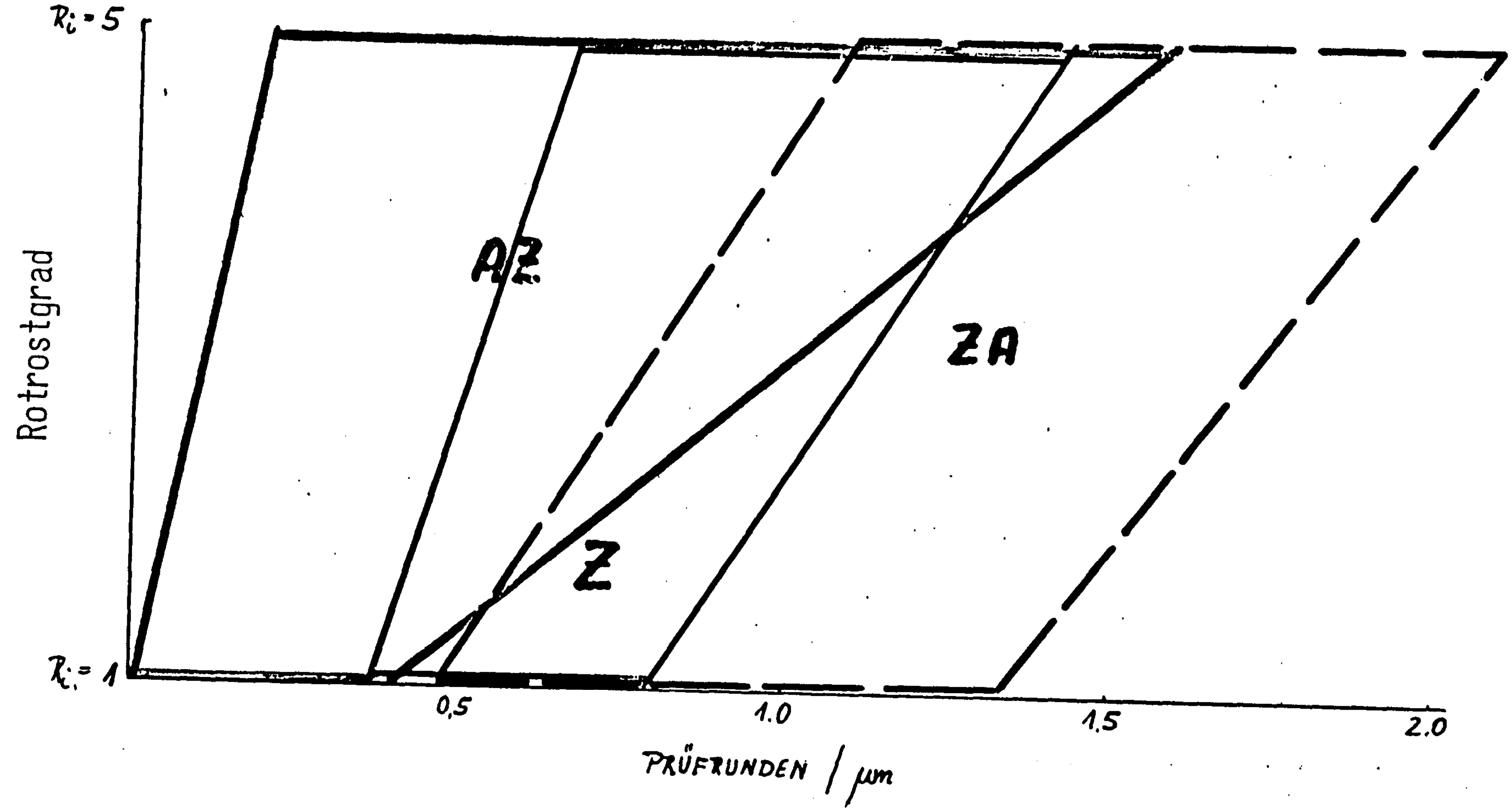


Bild 4: SO_2-Test nach DIN 50 018 – SFW 2.0 S
Abhängigkeit des Rotrostgrads vom
Verhältnis Prüfrunden/Schichtdicke

PAINTABILITY

INTRODUCTION

GALFAN, the new generation zinc-5% aluminum-mischmetal alloy coating for steel is becoming generally accepted as the best hot-dip substrate available for painting, based on its ability to accept a wide range of paint pretreatments, primers, and topcoats.

The process for the preparation and painting of GALFAN sheet is described. This description is intended to be very general, and therefore, adaptable to any existing commercial paint(ing) system.

THE PROCESS OF PAINTING GALFAN

More and more, it is becoming evident that GALFAN is the substrate of choice for the purpose of painting. Ongoing tests by independent paint companies/suppliers continually point to GALFAN for excellent performance and consistent results.

With little or no modification to existing paint systems, GALFAN presents no problems for painting. GALFAN is easily prepainted or post-painted. And, because GALFAN will remain passivated longer than conventional galvanized or Galvalume, the coating alloy-paint system bond will remain stable for a longer period of time.

Before painting, the surface of GALFAN-coated sheet must be treated to eliminate corrosive salts, fatty residues which come from oiling or handling, and solid residues which come from sources such as dust. This is done by degreasing with solvents or detergents which are generally neutral to alkaline in character. It is necessary many times to mechanically agitate the solution using brushes or sprays. Also a temperature around 70°C is used in many cases. The GALFAN-coated sheet is rinsed after this cleaning and then taken to a chemical conversion tank which changes the surface of GALFAN to a compound which will accept the paint. In general, phosphoric or chromic compounds are used. After this treatment, the operator must be very sure that the sheet is not subject to a dewpoint which would cause condensation on the treated surface. The dried surface is then ready for priming. The purpose of the primer is to tie the prepared GALFAN surface to the topcoat.

Several types of primers are commercially used. These include air drying paints such as the organic solvent based paints, water diluted paints, reactive paints (wash primers), and vinyl based paints. Bake drying primers include the epoxies, modified esters, acrylics, and polyesters. After leaving the primer part of the coil coating line, the prepared surface is then ready for top coating. Topcoats are sold as air drying paints which include alkyds, vinyls, acrylics, and polyesters. Bake drying topcoats include the one component paints such as alkyds, vinyl chloride-vinyl isobutylether copolymers, chlorinated rubbers, and water diluted paint such as acrylics. Two component bake drying paints include the epoxy/polyamide, acrylic/urethane, and polyurethane systems.

A recent development is powder painting. No primer is generally used when powder painting. The paint is applied with an electrostatic gun. Paints applied in this way include epoxies, polyesters, epoxy-polyesters, and polyurethanes.

Coil coating of GALFAN can be done using the standard paint systems and pretreatments employed on all conventional hot dip and electrogalvanizing coatings.

Some recommended pretreatments (courtesy Weirton Steel, U.S.A.) include:

- Parker B-1421, a high nickel, fine grain zinc phosphate
- JME-2-1-200, a chromic acid pretreatment
- Parker B-1303, a mixed oxide cobalt alkaline system
- Parker B-37-S, a zinc phosphate
- Parker 1415A - Dried-in-place Chromate

Primers used with GALFAN have shown excellent performance. Epoxy, urethane, and water-based acrylic primers have been used. The best results are seen with epoxy and urethane primers.

Topcoats used with GALFAN include polyester, silicon polyester, ceramic pigmented silicon polyester, fluorocarbon (70% Kynar 500 PVF2), plastisol, ceramic pigmented plastisol, urethane, and water-based acrylic. Dry film thicknesses of between 15 and 100 microns have been used with good results. Selection of the proper paint system is important for obtaining optimal results for coil coated GALFAN. With the proper paint system, coil-coated GALFAN exhibits corrosion resistance equal to or better than conventional galvanized and Galvalume. For optimum results, such a "proper paint system" can be custom designed, based on the end-use requirements. The steel producer, steel painter, pretreatment supplier, and paint suppliers can all coordinate to fit a proper paint system to a specific end use.

GALFAN is well-known for its outstanding formability. This advantage is again accentuated when considering prepainted GALFAN. Here again, the limiting factor is not the ductility of the GALFAN coating, but the steel substrate and/or the paint coating. The combination of GALFAN with a compatible paint system yields a coil coating system highly resistant to corrosion. The surface of GALFAN possesses the enhanced ability to remain passivated for very long periods of time, thus providing a substrate-paint system bond that remains stable for extended periods of time. The use of prepainted GALFAN allows consideration of applications involving extreme deformation or deep drawing, where previous use of galvanized steel was not at all possible, or dictated the necessity to paint after forming, a much more expensive alternative. Such a painted, formed part will now exhibit a longer life span, given the superior corrosion resistance of formed GALFAN.

Painted GALFAN is also very resistant to crazing. For example, in Zero-T and Three-T bend tests, GALFAN does not show the spangle cracking displayed by conventional galvanized steel coatings which tend to develop an "orange-peel" surface.

PERFORMANCE OF PAINTED GALFAN SHEET

The excellent long-term results of painted GALFAN sheet steel are supported by independent tests of paintability performed by various organizations. The results presented here include some examples of laboratory testing on painted GALFAN. All other results are based on long-term outdoor exposure, which are the best tests for evaluating materials, since they are an indication of real life results. Specific sources of the test material and results are noted.

DuPont Test Results

E.I. DuPont de Nemours & Company, Inc., have five-year evaluations of acrylic and polyester topcoats over epoxy primed and unprimed GALFAN panels that were treated with Bondcoat #1 by Heatbath Corporation. The panels are still under exposure in the humid, marine environment of southern Florida in the United States. The six-year date of exposure was achieved on July 26, 1990. It was visually reviewed by DuPont personnel, noting that there were little if any changes, so the decision was made to leave the samples out in the exposure site.

Table 1 presents the results of inspection regarding corrosion resistance. Changes since the forty-eight (48) month inspection (Table 1A) were minimal.

Weirton Steel Test Results

Weirton Steel Corporation of the United States previously presented the following data at a GALFAN Licensee Meeting held in Pittsburgh, Pennsylvania, U.S.A., in May 1987. All of the following test results are based on laboratory tests, actual long-term outdoor exposure tests are currently underway.

1000 Hours Salt Spray (ASTM B-1117):: Salt spray testing of various paint systems over GALFAN revealed the following:

-**Edge Creep** - With equivalent paint systems, GALFAN revealed excellent resistance to edge creep similar to, and in many cases, better than conventional galvanized, and better than a 55% Al, 43.5% Zn, 1.5% Si product.

-**Scribe** - GALFAN revealed less scribe creep and blistering around the scribe than the 55% Al, 43.5% Zn, 1.5% Si product, and in most cases, equivalent or better than conventional galvanized.

- **Face or Field** - With many of the paint systems tested, the face or field revealed no blisters.

- Zero-T Bends and 80-Inch-Pound Direct and Reverse Impact Tests -

-With the proper paint system (more flexible primer and/or top coat formulations), no blistering or corrosion products were encountered with the GALFAN.

-With comparable paint systems, the Zero-T bends revealed less corrosion products on GALFAN versus the 55% Al, 43.5% Zn, 1.5% Si product, and conventional galvanized.

<u>1000 Hours 100% Relative Humidity (ASTM D 2247):</u>

- No blisters or corrosion products were observed on any of the GALFAN panels.

<u>1000 Hours and 240 Hours Cleveland Condensing Humidity (140°F Q.C.T.)</u>:

- All of the paint systems with the exception of the water-based primers, revealed good results with no blistering being revealed on the face of the panels.

- Panel bends and 80 inch-pound impacts revealed no corrosion products, and only a few micro-blisters on some of the bends.

<u>Detergent Resistance - 240 Hours at 165°F (ASTM D 2248)</u>:

- The paint systems in which the advanced technology zinc phosphate (high nickel) pretreatment was used, performed the best in terms of edge creep, blistering, etc.

<u>Kesternich (2 Liter SO2) - D.I.N. 50018</u>:

- Conventional thin film paint systems went 16 cycles without any blisters, and 30 cycles with (number) 7-8 fine blisters. The cut edge corrosion ranged from 1.0 mm to 2.0 mm after 30 cycles.

- The thick film primer (0.8 mil) paint system went 31 cycles without any blisters. The cut edge corrosion was 2.0 mm after 31 cycles.

SOLLAC Test Results

SOLLAC of France has submitted photographs of the results of seven (7) years outdoor exposure of prepainted GALFAN and prepainted galvanized at a marine (Biarritz) site. The paint system(s) details are as follows:

Polyester:	Primer: PPG E 100 J 011 Finish: PPG Polycron
PVdF:	Primer: CASCO NOBEL Ripox 2040 Finish: CASCO NOBEL Ripofluor
PVC:	Primer: AKZO 7 B 1516 Finish: AKZO Superclad

Figures 1, 2, and 3 show prepainted galvanized and prepainted GALFAN as noted.

Yodogawa Test Results

Yodogawa Steel Works of Japan markets their prepainted GALFAN with the trade name of YODO-GALFAN COLOR. Figure 4 illustrates the performance of prepainted YODO-GALFAN COLOR compared to a like sample of prepainted galvanized steel after 1800 hours of salt spray testing. The superiority of the prepainted GALFAN is obvious. As is commonly known, a normal paint topcoat offers barrier protection, but all paint topcoats are permeable to some extent. It can be seen that the zinc coating on the galvanized sample has cracked on the impact dimple, exposing the steel substrate to the corrosive media of the salt spray resulting in the white corrosion products. There is no sign of any kind of damage on the prepainted YODO-GALFAN COLOR.

Sumitomo Metal Industries Test Results

Another GALFAN sheet process licensee, Sumitomo Metal Industries of Japan, presented results of their studies on the corrosion resistance of prepainted GALFAN compared to prepainted galvanized steel. These results were presented at a GALFAN Licensees Meeting in Osaka, Japan, January 1989. Figures 5 and 6 illustrate the combination of corrosion resistance and formability of prepainted GALFAN. Figure 5 shows results of 880 hours of salt spray testing with an edge-on view of a 2-T bend. Once again, the superior crack resistance of GALFAN is obvious. There are no corrosion products present. Figure 6 shows results after 1500 hours salt spray testing on an edge-on view of a 10-T bend. Once again, the superior performance of prepainted GALFAN can be observed.

More convincing are the results of actual long-term outdoor exposure. Sumitomo continued their studies with five-year outdoor exposure panels, as illustrated in Figure 7. The test panels were exposed in a severe tropical marine site in Okinawa, Japan where the panels are subject to high humidity, high ultraviolet exposure, and a high degree of direct salt spray. After five years, the prepainted GALFAN still looks almost new, whereas the prepainted galvanized panel is very badly corroded.

Another interesting conclusion reached by Sumitomo Metal Industries is that GALFAN is the best available substrate for heavy gauge applications. Based on electrochemical measurements of laboratory tests, Sumitomo has concluded that prepainted GALFAN offers superior cut edge protection as compared to prepainted galvanized as well as prepainted Galvalume, especially so as the base steel gauge increases. This work confirms previous ILZRO research claims (ILZRO project ZM-285, CRM Progress Report Number 19) that GALFAN provides the best available cut edge/scratch cathodic protection.

New Zealand Steel Test Results

New Zealand Steel, one of the first sheet licensees for the GALFAN process, is preparing for the eventual production of GALFAN by studying the performance of prepainted GALFAN, because most of their market would be for prepainted construction panels. New Zealand Steel has been studying GALFAN continuously since 1981 when GALFAN was first invented. As an island country, almost every application of prepainted coated sheet in New Zealand would be subject to marine or severe marine conditions. Based on their results as shown here, New Zealand Steel believes that GALFAN is a product they would like to produce as soon as possible.

Figure 8 shows two prepainted roll formed panels. On the left side is prepainted galvanized steel, on the right side is prepainted GALFAN. The next two figures show cross sectional micrographs taken across the tension bend of the roll formed rib after twenty months of severe marine exposure. Figure 9 is a magnification of the tension bend of the prepainted galvanized steel (Figure 8 - left side). As can be easily seen, the zinc coating on the tension bend of the rib has cracked and exposed the steel substrate to corrosive atmosphere. The cracks have filled with zinc corrosion products, not only undermining the topcoat and lifting it off the primer, but spilling over onto the top surface of the topcoat resulting in cosmetically objectionable white marks. Figure 10 is a magnification of the prepainted GALFAN panel (Figure 8 - right side). As one can see, the GALFAN has not cracked but the paint and the primer have. Since there are no extensive corrosion products, the surface appears (from normal viewing distances) to be in excellent condition.

Prepainted galvanized steel (Figure 11) and prepainted GALFAN (Figure 12) are compared after two and one-half years at New Zealand Steel's severe marine exposure site. The coating weight of the prepainted galvanized sheet is 400 g/m^2 total. The coating weight of prepainted GALFAN sheet is 292 g/m^2 total. The paint systems are identical (epoxy primer and polyester topcoat). There are no blisters or corrosion products present on GALFAN, confirming its superior performance. After six years, as shown in Figure 13, the same types of exposure panels again show that prepainted GALFAN is far superior to prepainted galvanized. Utilizing the silicon modified polyester topcoat (with similar coating weights, approximately 400 g/m^2 total) galvanized and GALFAN panels again show the superior performance of GALFAN after six years of severe marine exposure, as shown in Figure 14.

Figures 15 - 20 illustrate various paint systems on GALFAN and galvanized exposed by New Zealand Steel. Table 2 lists the relevant details of exposure. As New Zealand Steel stated in their own internal report, "seeing is believing."

Of considerable significance is the fact that the GALFAN used in New Zealand Steel's tests was the product of the first-ever industrial production trial of GALFAN. It was produced by Ziegler (Now SOLLAC - Mouzon) of France in 1981. Since that time, through continuing research and licensee experience, the process for making GALFAN sheet has been refined so that the GALFAN of today is a superior product to that of 1981. New Zealand Steel has concluded this same fact and plans to produce GALFAN as soon as possible.

<u>Summary</u>

1. GALFAN is an excellent substrate for painting with little or no modifications necessary to existing paint processes. A major attraction of GALFAN is the relative ease with which existing facilities may be adapted for painting GALFAN.

Summary (contd.)

2. GALFAN is easily prepainted or post-painted using conventional techniques. Laboratory and field testing have demonstrated that adherence, appearance, and performance of pre- or post-painted GALFAN is excellent.

3. GALFAN will remain passivated longer than conventional galvanized or Galvalume. Therefore, the GALFAN/paint system bond remains stable for a longer period of time.

4. Licensee experience has proven that prepainted GALFAN is superior to prepainted galvanized steel in accelerated corrosion tests as well as actual long-term outdoor exposure. This superiority manifests itself in three major areas. The overall corrosion resistance of GALFAN, repeatedly proven to be two to three times better than that of conventional galvanized steel, provides a coated steel substrate that in itself is longer lasting. Then, the superior formability of GALFAN allows for deformations previously unattainable with conventional galvanized steel, which will crack and cause degradation of the steel substrate as well as the paint itself. Lastly, the superior galvanic/cathodic edge protection properties of GALFAN allow for cut edge/scratch protection superior to that of conventional galvanized steel based solely on the fact that GALFAN remains at the site of corrosive attack for longer periods of time, providing protection to the bare steel.

TABLE 1

GALFAN COATED PANELS - FIVE YEARS 45°S EXPOSURE

Panel Number	Customer Coil Number	Primer	Remarks
F-1	1	YES	No Rusting - Very Slight Edge Blisters
F-2	1	NO	Very Slight Rusting. Definite Edge Blisters and Slight Face Blisters
F-3	2	YES	Very Slight Rusting. Very Slight Edge Blisters
F-4	2	NO	Very Slight Rusting. Definite Edge and Face Blisters
F-5	4	YES	No Rusting. Very Slight Edge Blisters.
F-6	4	NO	No Rusting. Definite Edge and Face Blisters.
F-7	5	YES	Very Slight Rusting. No Blistering.
F-8	5	NO	Very Slight Rusting. Definite Edge and Face Blisters.
F-9	6	YES	No Rusting or Blisters.
F-10	6	NO	Slight Rusting. Severe Edge and Face Blisters.
F-11	9	YES	No Rusting or Blisters.
F-12	9	NO	No Rusting. Definite Edge Blisters and Very Slight Face Blisters.
F-13	10	YES	No Rusting or Blistering.
F-14	10	NO	No Rusting. Definite Edge Blisters and Very Slight Face Blisters.
F-15	12	YES	No Rusting. Very Slight Edge and Face Blisters.
F-16	12	NO	No Rusting. Definite Edge and Face Blisters.
F-17	15	YES	No Rusting. Very Slight Edge and Face Blisters.
F-18	16	YES	No Rusting or Blistering.
F-19	17	YES	No Rusting. Trace Edge and Face Blisters.
F-20	17	NO	No Rusting. Definite Edge and Face Blisters.
F-21	18	YES	No Rusting. Definite Edge and Slight Face Blisters.
F-22	18	NO	Very Slight Rusting. Definite Edge and Face Blisters.
F-23	-	YES	No Rusting. Very Slight Edge and Face Blisters.
F-24	-	NO	No Rusting. Definite Edge and Face Blisters.
F-25	-	YES	Very Slight Rusting. Very Slight Edge and Face Blisters.

TABLE 1A

GALFAN COATED PANELS - FOUR YEARS 45°S EXPOSURE

Panel Number	Customer Coil Number	Primer	Remarks
F-1	1	YES	No Rusting or Blistering.
F-2	1	NO	No Rusting But Edge Blisters and Slight Face Blistering. Fair Adhesion
F-3	2	YES	No Rusting or Blistering.
F-4	2	NO	No Rusting But Definite Face and Edge Blistering. Poor Adhesion.
F-5	4	YES	No Rusting or Blistering.
F-6	4	NO	No Rusting But Definite Edge and Slight Face Blistering. Fair Adhesion.
F-7	5	YES	No Rusting or Blistering.
F-8	5	NO	No Rusting But Definite Edge and Face Blistering. Fair to Poor Adhesion.
F-9	5	YES	No Rusting or Blistering.
F-10	6	NO	No Rusting But Considerable Edge and Face Blistering. Fair Adhesion.
F-11	9	YES	No Rusting or Blistering.
F-12	9	NO	No Rusting But Slight Edge and Very Slight Face Blistering. Fair Adhesion.
F-13	10	YES	No Rusting or Blistering.
F-14	10	NO	No Rusting But Definite Edge and Slight Face Blistering. Fair Adhesion.
F-15	12	YES	No Rusting of Blistering.
F-16	12	NO	No Rusting But Definite Edge and Slight Face Blistering. Fair Adhesion.
F-17	15	YES	No Rusting or Blistering.
F-18	16	YES	No Rusting or Blistering.
F-19	17	YES	No Rusting or Blistering.
F-20	17	NO	No Rusting But Definite Edge and Face Blistering. Fair Adhesion.
F-21	18	YES	No Rusting But Slight Edge Blistering.
F-22	18	NO	No Rusting But Definite Edge and Face Blistering. Fair to Good Adhesion.
F-23	-	YES	No Rusting or Blistering.
F-24	-	NO	No Rusting But Definite Edge and Face Blistering. Poor Adhesion.
F-25	-	YES	No Rusting or Blistering.

TABLE 2

Figure	Preparation	Exposure	Substrate
15a 15b	Phosphate Aqualure 128 SMA AHI Brown	44 Months	ZM 300 Galvanized GF 292 GALFAN
16a 16b	Chromate Duraprime 150 Sicon IV M	44 Months	ZM 300 Galvanized GF 292
17a 17b	TD1421 B Dualprime Sicon IV	52 Months	ZM 300 Galvanized GF 292 GALFAN
17c	B373 Dualprime Sicon IV	52 Months	ZM 300 Galvanized
18a 18b 18c	Dualprime Polyester PC3200	95 Months	ZM 400 Galvanized ZM-300 Galvanized GF 292 GALFAN
19c 19b	Dualprime Sicon IV SMP Red Oxide	95 Months	ZM 400 Galvanized GF 413 GALFAN
20a 20b	Chromate Dualprime Sicon IV	95 Months	ZM 300 Galvanized GF 292 GALFAN

Hot Market in Galfan: Automotive Tubing

by Drs. J. F. Cole, President, and
F. E. Goodwin, Vice President, Materials Sciences
International Lead Zinc Research Organization

Ever since Galfan went into experimental production 10 years ago, the zinc-5% aluminum-mischmetal alloy has made substantial, steady gains in the marketplace so that worldwide production of Galfan-coated sheet steel is likely to top 300,000 metric tons by a good margin this year, bringing cumulative production to over 900,000 metric tons.

Galfan has had a rather remarkable history since its invention in 1979 by International Lead Zinc Research Organization, Inc. (ILZRO). After an experimental production run within two years, the product went commercial for both wire and sheet in 1982.

Going into May 1990, ILZRO had negotiated a total of 46 licenses for sheet, wire and tubing. The licenses are held by companies through-out the world, but the strongest concentrations are in Europe and Japan.

The newest licensee, as of May 1, is Caledon Tubing, Mississauga, Ontario. Three other companies are reported to be on "the verge" of joining the licensee fold, according to Marshall P. Roman, Director of the Galfan Technical Resources Center, which was set up by ILZRO in 1987 to handle licensing and technical development of Galfan. ILZRO, meanwhile, is continuing its research efforts at Centre de Recherches Metallurgiques, Liege, Belgium, where Galfan was invented and first produced on a pilot production line in their laboratory.

Galfan's formability, especially, along with its corrosion resistance and paintability, are the principal characteristics behind the immediate success of this coating. The formability is evidenced by the absence of flaking, cracking, and microcracking during commercial bending, roll forming, stamping, and deep drawing operations. This has permitted fabrication of components previously impossible with hot-dip coated steels and has led to increased stamping plant productivity. Galfan's corrosion resistance has repeatedly been demonstrated to be two to three times that of conventional zinc coatings, with no loss in sacrificial cathodic protection.

Automotive Tubing Upswing

The focus of Galfan activity in recent months has been the small-diameter tubing market in North America, with all known production going to the U.S. and Canadian automotive industries for such applications as transmission oil cooling lines, as well as power steering, vacuum, and, soon, brake lines.

Caledon's President, Antonio Rea, expects to be ready for full Galfan tubing production by July or August this year. He said the company presently was producing its 3/16 to 3/8 in. diameter tubing with a terne (lead-tin) coating that is topcoated with zinc rich paint. He added that Caledon will modify its current terne line to make it a dedicated Galfan line.

Rea said the company decided to switch to Galfan on its promise of longer life, "which is what our automotive customer wants." He added that the company produces some 200 million ft. of small-diameter tubing annually.

The Caledon activity points up a rather interesting anomaly in Galfan development. While the U.S. and Canada have lagged behind the rest of the world in Galfan sheet or wire production, they are the only countries presently involved in Galfan-coated tubing.

Arc Tube Inc., Sault Ste. Marie, Ontario, became the first -- and as of mid-May 1990, the only -- commercial producer of Galfan-coated tubing. Don Esson, Vice President and General Manager, said the Galfan-coated tubing is a much superior product to the fomerly terne-coated tubing, "especially now that we have added an aluminum primer coating over the Galfan."

Esson added that the aluminum primer has increased corrosion resistance of the Galfan-coated tubing "by at least another two-thirds," and that test sections of the new duplex coating have passed 3000 hours in a severe salt spray test.

Esson noted further that "so far as tubing goes, the auto industry is going to go to Galfan-coated tubing in place of terne." He said that the Galfan tubing has lived up to expectations, "doing what they said it would do."

At Ford Motor Company, which with the 1985 model year became the first company in North America to use Galfan-coated tubing, a spokesman said they are looking to improve corrosion resistance of the tubing even more so that "this would enable us to offer the 10-year warranty we are shooting for." Ford presently is using 3/8-in. diameter Galfan-coated tubing for transmission oil cooling lines.

He added that Ford is looking "at all kinds" of combinations of coatings, including PTFE epoxy paints over Galfan, to reach that 10-year warranty goal. However, he added that Ford is "sticking with terne" coated with zinc-rich paint, for brake line tubing. "But if the coatings we are looking at for the oil tranmission lines provide superior performance," he continued, "we might look at them for the brake lines."

Ford also is using Galfan-coated sheet for a three-piece shield assembly that surrounds and protects a plastic fuel tank from road and heat damage. The Galfan-coated sheet has good corrosion resistance and excellent formability, "which is what we particularly needed for that application."

John Hostetler, of Hostetler Engineering, Canton, Ohio, designed the coating section of the Caledon line, which was built in cooperation with Chemical Equipment Fabricating Co. He noted that one very unusual feature is that painting is part of the line, a capability that no other galvanizing line has, so far as he knows. "The Caledon line makes it, coats it, and paints it," he said. Hostetler added that he also has designed a Galfan coating line for another Galfan licensee, ITT-Higbie Baylock, Auburn Hills, Michigan, which is scheduled to get under way "soon."

Hostetler said Caledon probably will run about a million ft. of tubing for one of the big three auto makers in Detroit, taking about three months to do so, for potential use as fuel lines. This will all be test products which the automaker intends to check out fully before committing itself.

At Bundy Tubing, Warren, Michigan, Bob Palmer, Supervisor, Process Engineering, reports that the company, another recent Galfan licensee, has been doing development work on Galfan tubing, with a topcoating, on its pilot production line for about a year and a half now.

"We have run some product samples," he reported, "which we have supplied to our potential customers -- all automotive so far. These products are brake and fuel lines, which are now being tested by product engineers in the automotive companies contacted."

Palmer said that "it looks fairly positive for us right now, on the basis of our work to date." He added that Bundy has employed various kinds of topcoatings, including fluoral polymers and metal-rich or aluminum-rich epoxy type coatings, over the Galfan.

He added that Bundy probably will go into full production sometime in 1991. "We first have to be assured that the orders will be there in significant volume to justify our setting up the full line." He noted that if the full production line is built, it will be a duplex coating line that will apply both Galfan and a topcoat. While the production line being considered is pretty well identified, final designs have yet to be completed. He indicated that a minimum order of one million ft. of tubing annually would justify going ahead with the line. Palmer added that "we're in a fairly competitive industry, so I expect we'll all be doing something in this area, that is, Galfan-coated tubing."

"The rapidly accelerating growth in Galfan automotive tubing use is a classic example of market pull," stated Dr. Richard F. Lynch, Galfan Market Development Consultant to ILZRO. "Ford started using the product in 1984 with one supplier, and within two years had over 10 feet of Galfan tubing on every car and light truck built in North America. That caught the attention of not only tubing producers but the other car companies as well. The result is that five years later, GM and Chrysler have also specified Galfan tubing and the rush is on."

Lynch added: "But Ford also got the jump on the competition with

Galfan sheet steel stampings, starting wtih the 1989 model T-Bird and Cougar. Galfan tubing gave over double the corrosion life of the old product in Ford's brutal Arizona Proving Grounds Test, causing Ford to evaluate Galfan sheet formability as well. The result was a 1986 Galfan specification decision on what would become the "1989 car of the year."

Galfan Sheet Steel Growth

Galfan steel sheet also is coming in for its share of new attention in the U.S. as Wheeling-Pittsburgh Steel continues to move ahead in its efforts to modify its Cook-Nortemann galvanizing line so that it will be able to produce both conventional galvanized and Galfan-coated sheet. This line will be the first Cook-Nortemann line in the world to produce Galfan-coated sheet. There are eight Cook-Nortemann lines in the U.S. and one in Canada.

David Parrish, Director of Market Development at Wheeling-Pittsburgh, reported that the company has three galvanizing lines -- 36 in., 48 in., and 60 in., of which it is converting the 48-in. line. "It will be a convertible line; that is, usable for both conventional and Galfan galvanizing," he said, adding that "it should be ready to go into commerical production around March/April of 1991."

Part of the reason for the delay, he said, "is to dovetail the line outage that will be required to install the Galfan equipment with the outage that will be required to install an in-line tension leveler. Parrish said the tension leveler would yield a flatter sheet that will be of special interest to the construction market, which he expects will be Wheeling's major initial market. "However, we also expect to supply the automotive, appliance, and electrical equipment industries, among others," he added.

Parrish noted that converting the line from conventional flux to electroflux operation required unique engineering as there was no other such line or experience to draw from. "We had to resolve such questions, for example, as what size electrodes and rectifiers, where to place the tanks, and many others of this nature," he said.

Parrish said he expects the company's Wheeling-Corrugating Co. Division, which produces roll-formed construction products, to have "strong potential" for the Galfan product that Wheeling produces. "They already are a very active manufacturer and supplier of roll-formed products to that industry," he noted.

The adaptation of Wheeling's Cook-Nortemann line was made possible through development of a new electroflux process, patented by ILZRO, whereby the steel sheet metal initially goes through an electroflux bath in which a very thin zinc layer is applied to each side of a steel sheet.

With the ILZRO electroflux method, the electrocoated sheet is then sent through a standard Galfan bath. The thin zinc plated substrate permits the Galfan coating to fully and uniformly cover the steel surface, which it otherwise would not do if the sheet were run through a conventional flux bath.

ILZRO, with the aid of several flux manufacturers, developed the special flux to ensure proper wetting of the steel surface, thereby eliminating bare spots that might occur without such wetting. Further, if standard fluxes were used, the aluminum in Galfan would react with the flux, leading to excessive dross formation and aluminum depletion of the Galfan bath, which should be maintained around the 5% level for aluminum. The new electroflux process Wheeling is going to use overcomes these difficulties.

Meanwhile, Weirton Steel, the only Galfan-sheet producer in the U.S., continues running steadily with its Galfan line. Andy Celestin, General Manager- Marketing, reports that "we're still increasing the number of Galfan applications." He added that "the product is doing everything it's supposed to do." He said that Weirton is supplying Galfan-coated steel sheet to the automotive and construction industries, both of which he termed "big users," and to growing numbers of applications in the appliance and electrical equipment fields, among others.

Celestin said Weirton's production outlook for 1990 is for much the same as in 1989, this seeming lack of growth being due "mostly to the fact that we've had several production outages because of our modernization efforts." These actions to modernize their lines is "an ongoing program," he continued, "for which we won't see the full benefit till around 1991."

Industry sources seem agreed that Wheeling's entry into the Galfan sheet picture in the U. S. will be a benefit to Weirton, despite the new competition, because it assures customers of a second source of supply.

Major automotive, appliance, and pre-engineered metal building companies have firmly stated that they would like to use Galfan, but only when there is more than one domestic producer. That time has now come.

# # #

"Schedule 1"

ILZRO PATENT ESTATE: GALFAN

COUNTRY	FILING DATE	SERIAL NO.	PATENT NO.	ISSUE DATE
United States	03-18-81	245,172		
United States	08-02-82	404,405	4,448,748	05-15-84
Argentina	01-04-82	288,029	227,220	09-30-82
Australia	03-18-81	70796/81	544,400	10-21-85
Austria	03-18-81	E48,270		
Belgium	03-25-80	C20-26/8003	882,431	3-25-80
Belgium	01-16-81	C21-07/8101	887,121	1-06-81
Brazil	11-24-81	PI81 07944	8107944	5-31-88
Canada	03-24-81	373,746	1,175,686	10-09-84
Czechoslovakia	01-15-82	PV.323-82	261856	01-27-89
East Germany	01-15-82	APC 22 C/236 795/5	220,342	3-27-85
European (EPC)		81-901054.7**	0048270	8-14-85
Finland	11-20-81	813,715	70254 0	9-15-86
France	03-18-81	E0048270		
India	12-21-81	1437/Cal/81		
Italy	12-30-81	68730-A/81	1,210,618	9-14-89
Japan	03-18-81	501400/1981	1541930	1-31-90
Korea	12-29-81	5,198/1981		
Liechtenstein	(See European - EPC)			
Luxembourg	03-18-81	E48,270		
Mexico	01-15-82	9872		

COUNTRY	FILING DATE	SERIAL NO.	PATENT NO.	ISSUE DATE
New Zealand	01-14-82	199,491	199-491	4-09-86
Netherlands	03-18-81	E48,270		
Poland	02-24-82	P235,209	136,815	11-18-87
Russia	11-24-81	336.1151/02	1,301,320	3-30-87
South Africa	01-07-82	82/0091	82/0091	11-24-82
Spain	01-15-82	508,771	508,771	5-03-83
Sweden	03-18-81	81-901,054.7		
Switzerland	03-18-81	E48,270		
Taiwan	01-16-82	7110131	17,916	11-01-82
United Kingdom	03-18-81	E48,270		
West Germany	03-18-81	P3171 770.5		
Yugoslavia	01-12-82	P-57/82		
Patent Cooperation Treaty	03-18-81	PCT/US 81/00347		

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

ELECTROFLUX PATENT

COUNTRY	FILING DATE	SERIAL NO.	PATENT NO.	ISSUE DATE
United States	10-15-86	919,255	4,738,758	04-19-88

Revised 6/90

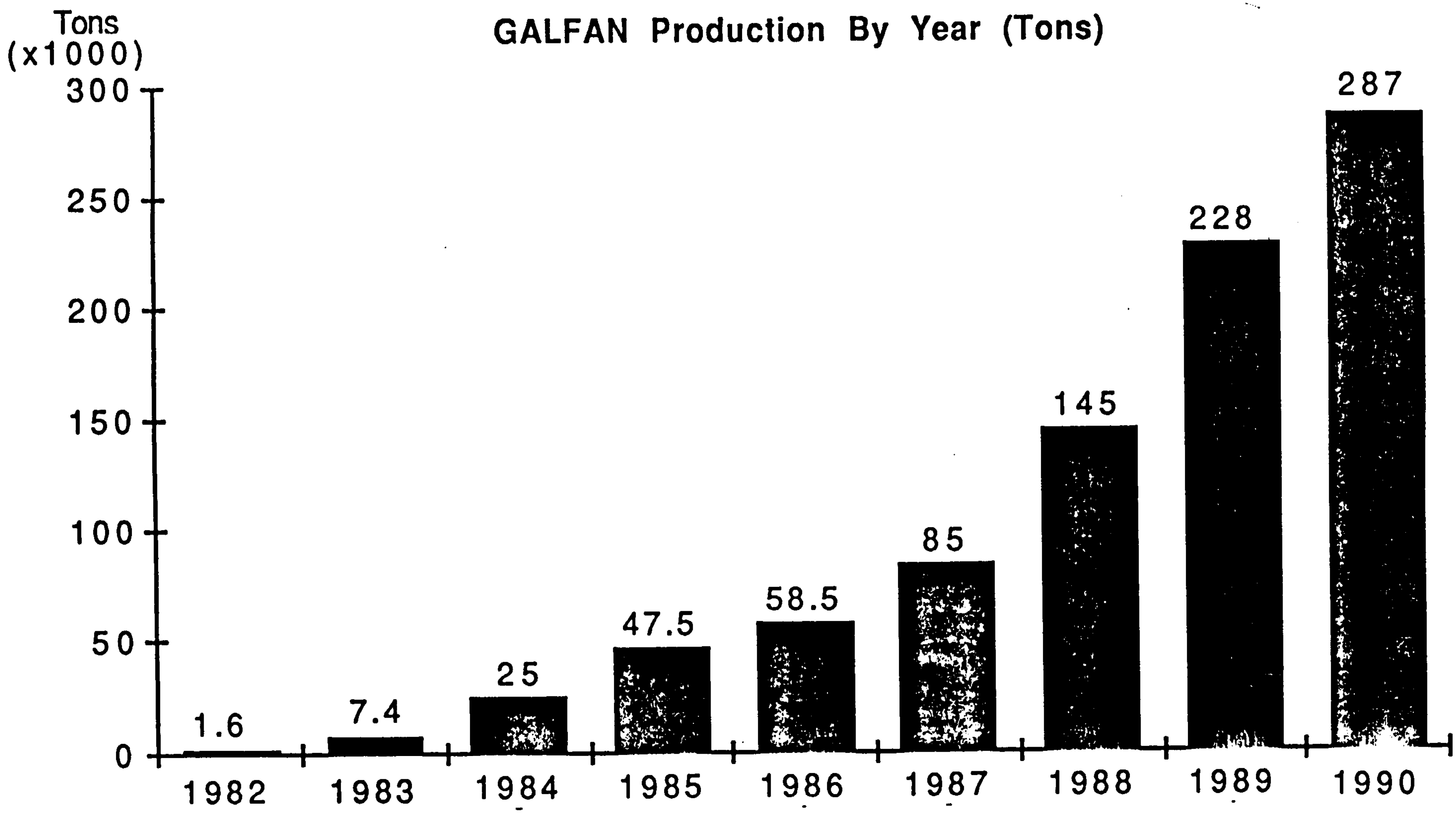
GALFAN TONNAGE

Company Name	1989 Tonnage	1990 Forecast
Altos Hornos de Vizcaya, S.A.	-	-
An Mau Steel Company, Ltd.	-	-
Arbed Research	4,200	5,000
Arc Tube Inc.	1,750	1,800
NV. Bekaert S.A.	4,000	4,000
British Ropes Ltd.	-	-
British Steel plc	-	-
Bundy Corporation (Bundy Tubing)	-	-
Caledon Tube	-	-
Cockerill Sambre/Branche Phenix	-	-
Coil Steels Group Pty., Ltd.	-	-
Empresa Nacional Siderurgica S.A. (ENSIDESA)	1,817	OPEN
Fabrique de Fer de Maubeuge (FFM)	-	-
Florida Wire & Cable Company	-	-
Gregory Galvanizing & Metal Processing Inc.	500	370
Hari Krishan Coated Sheets, Ltd.	-	-
Hoesch Stahl AG	57,200	80,000
Indiana Steel & Wire (IS&W)	0	500
Industrie Cantieri Metallurgici Italiani (ICMI)	2,500	3,500
Inland Steel Company	0	2
Iscor, Ltd.	-	-
ITT-Higbie Mfg. Co.	-	-
Kawasaki Steel Corp. (Kawatetsu Galv.)	10,241	10,400
Kawasaki Steel Techno-Wire Corp.	70	600
Kobe Steel Ltd.	-	-
Maruichi Steel Tube Ltd.	0	3,000
Munak Galva Sheets, Ltd.	-	-
New Zealand Steel Limited	-	-
Nippon Denro Ispat, Ltd.	-	-
Nisshin Steel Company, Ltd. (2)	71,230	96,500
NKK Corporation	2,131	2,000
Palmer Tube Mills (Pty) Ltd.	-	-
Rautaruukki Oy	8,500	3,300
Stahlwerke Peine-Salzgitter AG	2,500	3,000
SOLLAC (USINOR - SACILOR)	7,000	14,000
STELCO, Inc.	-	-
Sumitomo Metal Industries, Ltd.	22,000	25,000
Svenskt Stal, AB (SSAB)	-	-
Thyssen Stahl A.G.	0	1,000
TREFILUNION-Lens (FICAL)	1,685	2,500
Voest Alpine Stahl GmbH	-	-
Weirton Steel Corporation	19,000	18,200
Wheeling-Pittsburgh Steel Corp.	-	-
Yodogawa Steel Works, Ltd.	11,670	12,500
TOTALS	227,994	287,172 + 26%

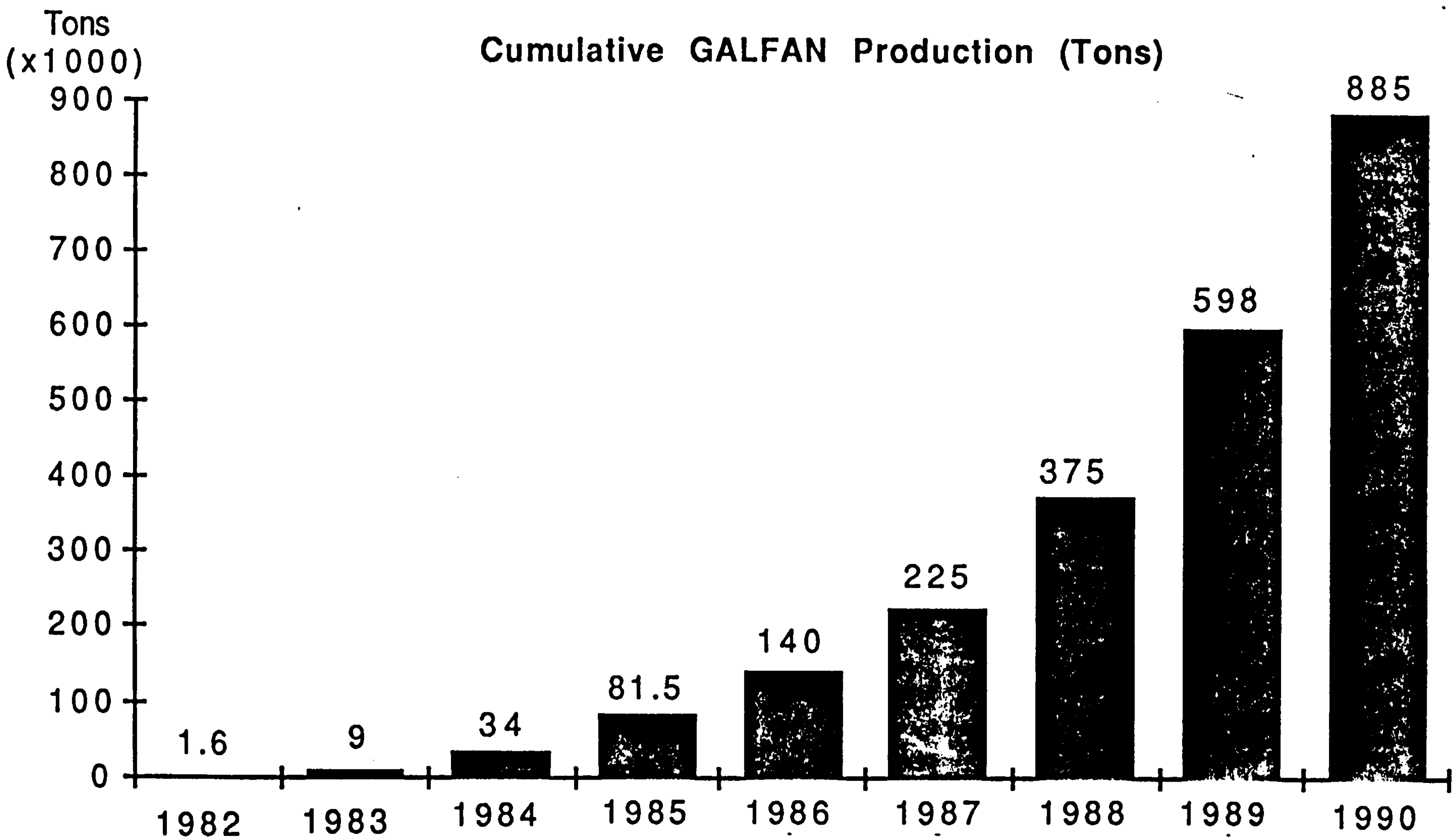
All Figures Are In Metric Tons

YEARLY GALFAN PRODUCTION (TONS)

	1982	1983	1984	1985	1986	1987	1988	1989	1990
North America	0	0	500	500	4500	7000	18000	22000	21000
Europe	900	1400	11500	23500	23000	31000	47000	89000	116000
Japan	700	6000	13000	23500	31000	47000	80000	117000	150000
Yearly Total	1600	7400	25000	47500	58500	85000	145000	228000	287000
Cumulative Total	1600	9000	34000	81500	140000	225000	370000	598000	885000



GALFAN Production By Year (Tons)
Tons (x1000)
300
250
200
150
100
50
0
1.6
7.4
25
47.5
58.5
85
145
228
287
1982
1983
1984
1985
1986
1987
1988
1989
1990


Tons
(x1000)
Cumulative GALFAN Production (Tons)
900
800
700
600
500
400
300
200
100
0
1.6
9
34
81.5
140
225
375
598
885
1982
1983
1984
1985
1986
1987
1988
1989
1990

KAWASAKI STEEL Techno-Wire Corporation

Table 1 Amount of GALFAN wire products in Japan

Market fields		Amount of Products (Tons/month)	
		1990	1991
Telephone and telegraph	Overhead and communications cable, etc	30	50
Civil engineering	Guard cables	10	20
Automotive industry	Outer wire for control cable	10	30
	Other wire parts	0	10
Marine product industry	Ropes and wires	0	20

We may presume our conpany's share (GALFAN wire) is 10% of Japanese Zn-Al alloy coated wire-market.

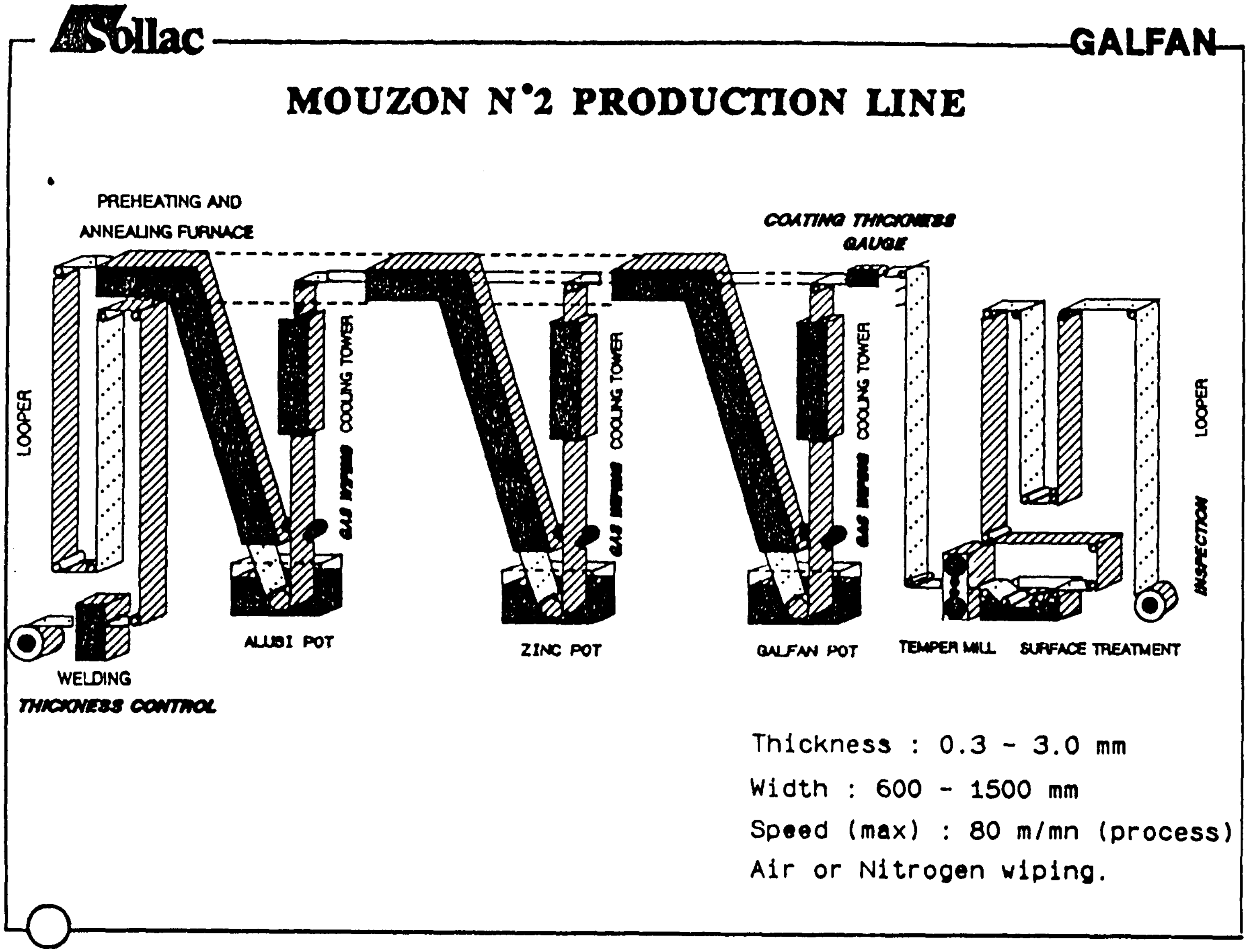

Sollac
GALFAN
MOUZON N°2 PRODUCTION LINE
PREHEATING AND
ANNEALING FURNACE
COATING THICKNESS
GAUGE
LOOPER
COOLING TOWER
COOLING TOWER
COOLING TOWER
LOOPER
INSPECTION
ALUSI POT
ZINC POT
GALFAN POT
TEMPER MILL
SURFACE TREATMENT
WELDING
THICKNESS CONTROL
Thickness : 0.3 - 3.0 mm
Width : 600 - 1500 mm
Speed (max) : 80 m/mn (process)
Air or Nitrogen wiping.

Figure 1

Sollac

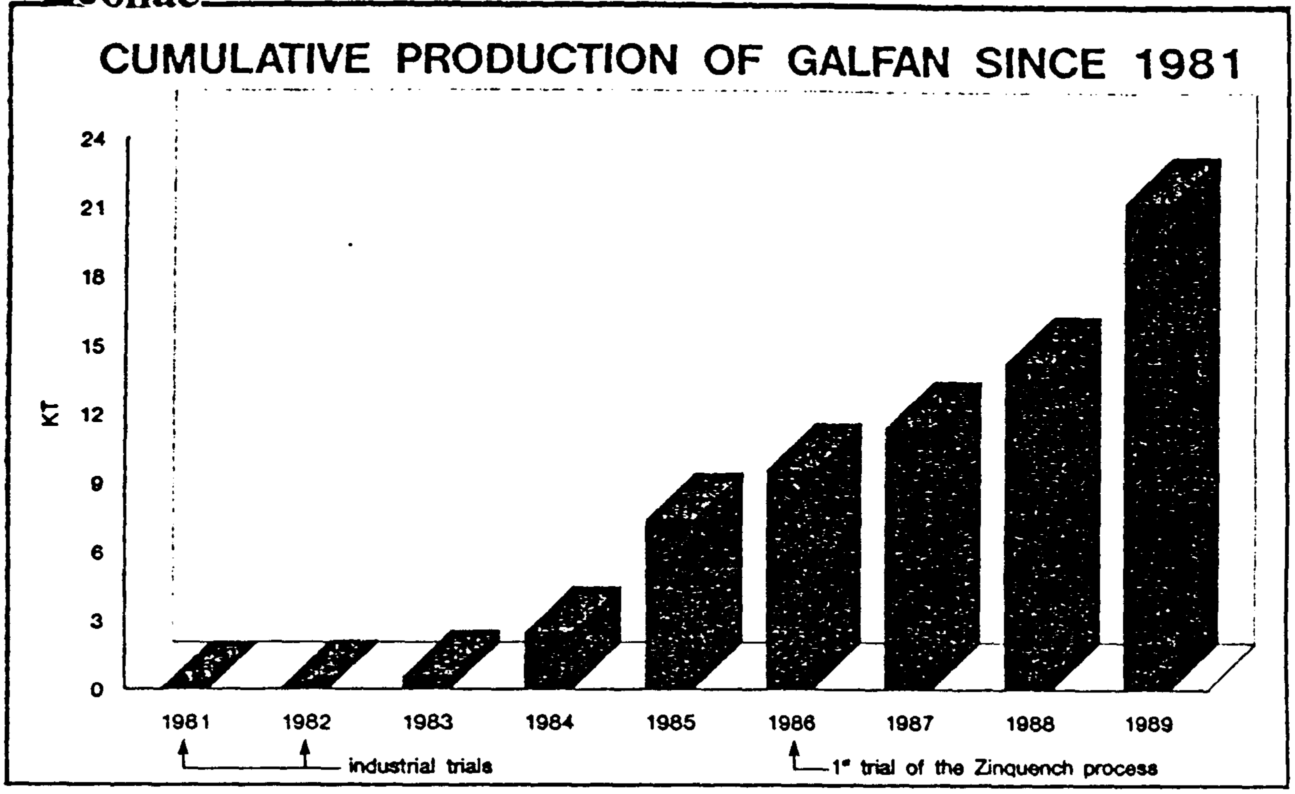
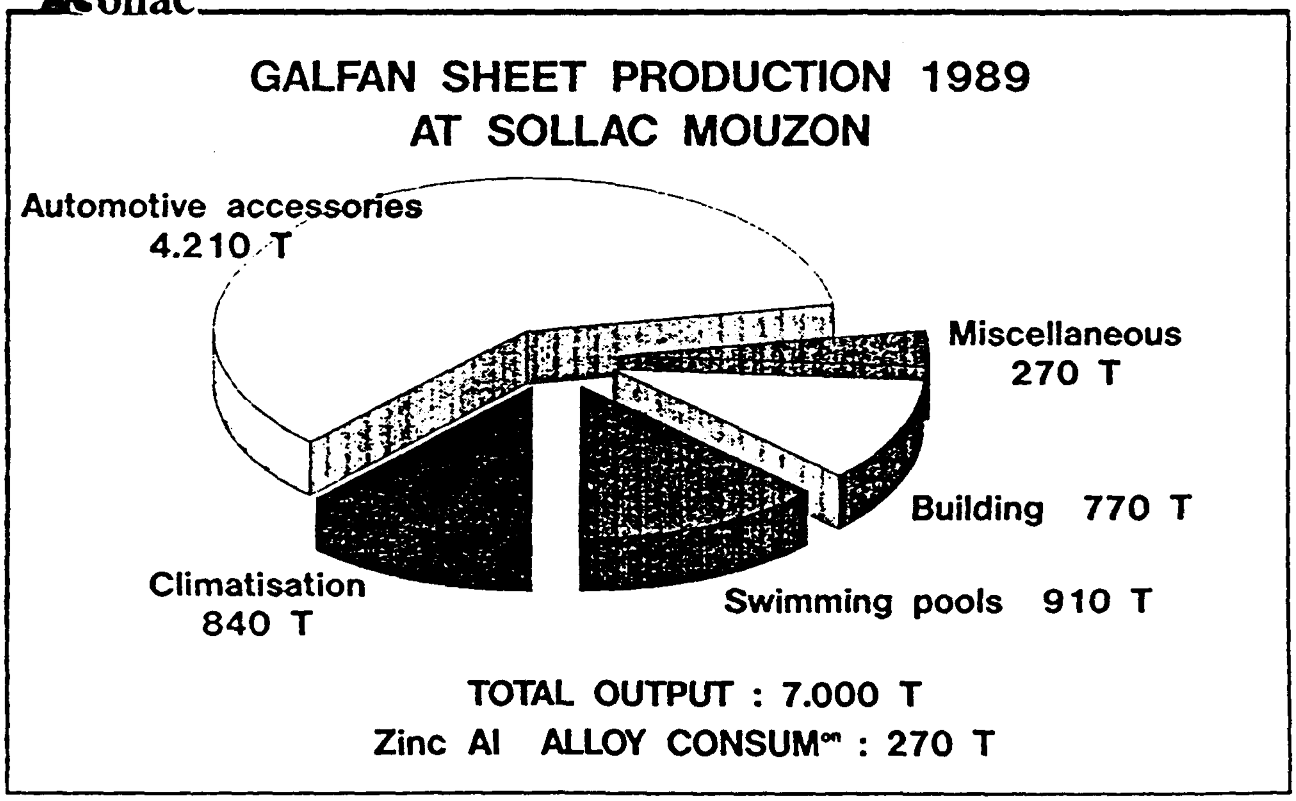


Table 2

Sollac



THE MARKETS OF GALFAN

Where do we go from here?

A strange question maybe but one which needs addressing and answering with positive actions. In order that we can answer the question we must first establish and confirm exactly where we are.

Amongst the meeting today we have some world known and established companies working in the three product areas of Galfan, Sheet, Wire and Tube. In turn each company has quite correctly identified their own specific market areas in which they wish to develop sales of GALFAN.

This each has done with considerable success. As each company has progressed with their own product so demand has increased. This in turn has forced other companies to follow suit and produce like products.

One example of this situation is the demands currently from Shell where they have offers of Galfan anchor lines for use in the Gulf of Mexico for their off-shore drilling rigs. Because of the size of this contract and the implications that other oil companies will also demand the same product wire companies and wire rope manufacturers are now looking more intently at taking on board Galfan than they have done in the past.

Thus we have a situation arising where wire/rope producers are imitating what the members here today are doing. "Imitation" after all is the greatest form of compliment which may be given. We must therefore extend own congratulations to those companies who have their imitators for without their initial success we would not see the growth in demand of Galfan.

I have no doubt that each Galfan producer has their own individual plans for the future of their own product. In order that each company may keep one step ahead of competitors then it is only natural that any such future plans will be kept "in-house" until the product is released on the market. This is normal commercial practice.

There are, however, certain drawbacks to this common commercial practice. The major drawback being that in todays competitive business world the Buyers/Purchasing Managers now look for alternative sources of supply. This is not just to play one company off against another in regards to prices, but purely to ensure continuity of supply, thereby the need of having a second supplier.

It is in part the purpose of this meeting, to allow Galfan producers to exchange ideas as to products and development of products.

How many times have we been in the situation where reports from the market place have informed us that "ABC" company are selling a new type of product. This is then confirmed, investigated and then the question - Can we do the same? More often than not you have no choice you have to make the same or better. This involves duplication of effort and a considerable amount of time.

Would it not be easier once you have developed a new product line to find a "partner" and introduce your new product to him, with of course, certain safeguards to yourself and your company. This would allow you to more rapidly achieve market penetration, as the effort would be doubled but with the advantage you would keep the main control.

This may be an idealists dream but one which is quickly becoming a reality when you consider the demands and expectations of the Buyer/Purchasing Manager. It already happens of course in the larger multi-national companies.

So if we revert back to my original question - (Where do we go from here ?)Galfan has established itself through your goodselves as a good and competitive product with growth potentials in the now established market sectors.

As I see it, new growth must therefore come from two areas. Firstly, new products or maybe replacements of outdated products ready to have a new breath of life put in to them and secondly, the market place itself.

New products is in itself explanatory as each individual company you will have your own plans for new products. You may, however, see existing traditional products, which could be improved with the use of Galfan, thereby increasing the value of the product.

Allow me to give an example of a traditional product which could be improved by a Galfan coating. Mild steel wire chains have reached their maximum sales peak. I suspect there are no new markets or applications of which chain can be used which has not already been tried. However with a Galfan coating giving extended corrosion resistance therefore extended life the common chain could find a new lease of usefull life.

Another example is regaining a market lost to plastics i.e. building rain guttering and fall pipes. The market was lost to the strip and tube manufacturers to plastics due in part to the extended life of plastics and the lower price. However it is now seen the limitations and problems of plastics namely that over a period of time the plastics crack, they do not enjoy the same strength as steel and special primers are need to allow them to be painted. Now with Galfan we have extended life (corrosion resistance) strength, and paintability. Hence with the use of Galfan a market area may be regained.

Demands from the market place, however, is an area of which I see the greatest new potential. Allow me to explain further.
As is the nature of man we are engrossed in the advancement of our own individual products. To a degree we are entrenched, almost hypnotized, by what we have done in the past and as such new ideas are more difficult to comeby, however, out in the big wide world, there are people not trapped by the sole idea of production of steel sheet or tube or wire, but have a wider view of the world because of their own environment

It is from this group that new ideas will flow. The task, however, is the manner in which to capture these ideas.

Market awareness of the product is in part the answer and as such we all must make greater efforts to ensure that the world markets are aware of GALFAN.

Market awareness is the natural progressive step for ILZRO however ILZRO needs your guidance in this aspect.

End users or potential end users are the people we need to be approaching, of course we need the backup of an end product from yourselves to seek out the end-user, i.e. the ultimate customer.

Ideas are invited from the floor (meeting) as to your perception as to new areas for GALFAN to develop.

J. J. Hogan.
Brailsford Wire Supply Ltd.
Derby U. K.

GALFAN AUTOMOTIVE TUBING
-MARKET DEVELOPMENT TIMELINE-

1983 - PROPOSAL TO *FORD* -GALFAN TUBING TO REPLACE TERNE
- GALFAN PASSES 1000 HOUR SALT SPRAY TEST

1984 - GALFAN TUBING APPROVED @ FORD; SPEC. WRITTEN
- ARC TUBE-CANADA STARTS MANUFACTURE
- AUTOMOTIVE TRANSMISSION OIL COOLER LINES START AT FORD ON ALL NA 1985 MODEL CARS & LIGHT TRUCKS

1985 - GALFAN TUBING PASSES 60 CYCLES ARIZONA PROVING GROUNDS TEST; TERNE FAILED BEFORE 30 CYCLES
- FORD USAGE EXPANDS TO INCLUDE: VACUUM LINES, POWER STEERING LINES & OTHERS
- (FORD STARTS CORROSION EVALUATION OF GALFAN SHEET)

1986 - FORD USAGE EXCEEDS 10 FT AVERAGE PER CAR & LIGHT TRUCK BUILT IN NA
- FORD RECEIVES ZI AWARD OF ENGINEERING EXCELLENCE
- (FORD CONDUCTS STAMPING PLANT SHEET TRIALS)
- (FORD APPROVES GALFAN SHEET FOR NON-WELDED USE)
- (FORD SPECIFIES GALFAN SHEET FOR FUEL TANK SHIELD FOR 1989 MODEL THUNDERBIRD & COUGAR)
- ("BIG THREE" START USING GALFAN DEEP DRAWN MOTOR HOUSINGS FROM SUPPLIERS)

1987 - BUNDY TUBING-U.S. STARTS GALFAN PILOT LINE TRIALS
- BUNDY INTEREST ALSO IN DOUBLE WALL BRAKE LINES

1988 - BUNDY SIGNS GALFAN LICENSE
- BUNDY EVALUATING 2000-3000 HOUR SALT SPRAY INCLUDING PVF COATED GALFAN
- (1989 MODEL FORD THUNDERBIRD & MERCURY COUGAR GO INTO PRODUCTION WITH THREE PIECE FUEL TANK SHIELD ASSEMBLY AS WELL AS GALFAN MOTOR HOUSINGS & TUBING; NAMED "1989 CAR OF THE YEAR")

1989 - *GM & CHRYSLER* COMPLETE TESTING & WRITE GALFAN TUBING SPECS
- HANDY HARMON-US INTERESTED IN GALFAN LICENSE
- ITT HIGBIE-U.S. SIGNS GALFAN LICENSE; 1990 PRODUCTION START PLANNED

1990 - CALEDON TUBING-CANADA SIGNS GALFAN LICENSE; 1990 PRODUCTION START PLANNED
- INTERNATIONAL INTEREST EXPRESSED BY TUBING MANUFACTURERS IN EUROPE & AUSTRALASIA BASED ON CUSTOMER INQUIRY

NOTE: GALFAN SHEET EFFORTS (IN PARENTHESIS) GENERATED FROM TUBING INTEREST.

GALFAN SPECIFICATION STATUS - NORTH AMERICA

ASTM-

INGOT & ANALYSIS

B750-88	GALFAN (ZN-5AL-MM) INGOT
EXXX	CHEMICAL ANALYSIS OF ZN-5AL-MM ALLOY (PROPOSED)

SHEET & SHEET PRODUCTS

A875/A875M-88	GALFAN COATED SHEET
A755/A755M-89	METALLIC COATED SHEET PRE-PAINTED BY COIL-COATING FOR EXTERIOR EXPOSED BUILDING PRODUCTS (GALFAN INCLUDED)

WIRE & WIRE PRODUCTS

A856/A856M-89	GALFAN COATED CARBON STEEL WIRE
A855/A855M-89	GALFAN COATED WIRE STRAND
B802-89	GALFAN COATED STEEL CORE WIRE FOR AL CONDUCTORS, STEEL REINFORCED (ACSR)
B803-89	GALFAN COATED HIGH STRENGTH STEEL CORE WIRE FOR AL CONDUCTORS, STEEL REINFORCED (ACSR)
A817-90	METALLIC COATED WIRE FOR CHAIN-LINK FENCE FABRIC (REVISED TO INCLUDE GALFAN AS TYPE III)

FENCING

F1234-89	PROTECTIVE COATINGS ON STEEL FRAMEWORK FOR FENCES (GALFAN INCLUDED @ 0.9 OZ/FT^2)
FXXX-XX	GALFAN COATED WIRE FOR CHAIN-LINK FENCE FABRIC (PROPOSED)

NOTE: ADDITIONAL SPECIFICATIONS ARE UNDER DISCUSSION FOR CORRUGATED PIPE FOR CULVERT, OTHER WIRE PRODUCTS, ETC.

AASHTO -

F1234-89 ALSO PROPOSED FOR AASHTO SPECIFICATION

AUTOMOTIVE TUBING -

ESA-M1A270-A	FORD (1984)
26019379	GENERAL MOTORS (1988)
PS8688	CHRYSLER (1988)

UNDERWRITERS LABORATORIES -

UL HAS APPROVED GALFAN COATED SHEET STEEL FOR USE AS AN ALTERNATIVE TO GALVANIZED:

GF60 $\geq$ G90
GF45 $\geq$ G60

UNIFIED NUMBERING SYSTEM -

Z38510	UNS DESIGNATION FOR THE GALFAN ALLOY PER B750 PER ASTM/SAE

INTERNATIONAL STANDARDS ORGANIZATION -

AN ISO GALFAN COATED SHEET SPECIFICATION WAS PROPOSED BY THE FRENCH DELEGATION AT THE SEPTEMBER 1989 ISO MEETING IN SWEDEN WITH SUPPORT FROM THE USA

GALFAN INTERNATIONAL, INC.

- GI IS A NEW COMPANY BEING FORMED TO MARKET & LICENSE GALFAN TECHNOLOGY WORLDWIDE

- NEGOTIATIONS ARE UNDERWAY TO PURCHASE THE GALFAN PATENT, TRADEMARK AND TECHNOLOGY ESTATE FROM ILZRO

- ILZRO WILL CONTINUE STRONG TECHNICAL & RESEARCH INVOLVEMENT IN GALFAN INCLUDING PARTICIPATION IN GALFAN LICENSEE MEETINGS

- EMPHASIS OF GI WILL BE BOTH MARKET & TECHNOLOGY ORIENTED INCLUDING SUPPORT TO LICENSEES

- LICENSEE PARTICIPATION WILL BE ENCOURAGED IN MARKET DEVELOPMENT EFFORTS

GALFAN INTERNATIONAL, INC.

GI STRUCTURE -

- GI WILL BE STAFFED TO ACHIEVE ITS OBJECTIVE OF RAPID AND STRONG GALFAN GROWTH

  - PRESIDENT

  - MARKET DEVELOPMENT MANAGERS IN:
    EUROPE
    NORTH AMERICA
    AUSTRALASIA

  - TECHNICAL RESOURCE MANAGER

  - OPERATING TECHNOLOGY MANAGER

  - BUSINESS DEVELOPMENT MANAGER

  - OTHER SUPPORT SERVICES

MARKET DEVELOPMENT APPROACH -

- EMPHASIS WILL BE ON BUILDING GALFAN MARKETS AND CREATING SIGNIFICANT NEW APPLICATION AREAS WORLDWIDE

- GALFAN'S SUPERIOR PERFORMANCE AND COST SAVING ADVANTAGES WILL BE EMPHASIZED INCLUDING CASE HISTORY EXAMPLES

- APPROACH WILL INCLUDE REGIONAL MARKET DEVELOPMENT PROGRAMS WITH PARTICIPATING LICENSEES

Working Document for Committee Use Only. Not for Publication except as Expressly Approved by the Chairman of Committee E-1 or the President of the Society.

Proposed New Standard Method
CHEMICAL ANALYSIS OF ZINC-5% ALUMINUM-MISCHMETAL ALLOYS
by the ICP ARGON PLASMA SPECTROMETRIC METHOD[1]
ASTM Designation: EXXX

Draft#1 , J.H.Kanzelmeyer
Draft#2 03/13/88, J.H.Kanzelmeyer, edited by T.F. Beckwith
Draft#3 04/06/89, Sub 3.05 balloted
Draft#4 10/12/89, Edited after 9/89 E-3 Meeting
Draft#5 05/16/90, Edited after 1/90 E-1 Ballot

1. Scope

1.1. This method covers the chemical analysis of zinc alloys having chemical compositions within the following limits:

Element	Concentration Range, %
Aluminum	3.0 - 8.0
Antimony	0.002 max
Cadmium	0.025 max
Cerium	0.03 - 0.10
Copper	0.10 max
Iron	0.10 max
Lanthanum	0.03 - 0.10
Lead	0.026 max
Magnesium	0.05 max
Silicon	0.015 max
Tin	0.002 max
Titanium	0.02 max
Zirconium	0.02 max

[1] This test method is under the jurisdiction of ASTM Committee E-1 on Analytical Chemistry of Metals, Ores and Related Materials and is the direct responsibility of Subcommittee E1.05 on Zinc, Tin, Lead, Cadmium, Beryllium and Other Metals.

1.2. Included are methods for elements in the following concentration ranges:

Element	Concentration Range, %
Aluminum	3.0 - 8.0
Cadmium	0.0016 - 0.025
Cerium	0.005 - 0.10
Iron	0.0015 - 0.10
Lanthanum	0.009 - 0.10
Lead	0.002 - 0.026

1.3. This standard may involve hazardous materials, operations and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. Referenced Documents

2.1. ASTM Standards:

D 1193 Specifications for Reagent Water[2]

E 29 Recommended Practice for Using Signigicant Digits in Test Data to Determine Conformance With Specifications[3]

E 50 Practices for Apparatus, Reagents, and Safety Precautions for Chemical Analysis of Metals[4]

E 55 Practice for Sampling Wrought Nonferrous Metals for Determination of Composition[4]

E 88 Practice for Sampling Nonferrous Metals and Alloys in Cast Form for Determination of Chemical Composition[4]

E 173 Practice for Conducting Interlaboratory Studies of Methods for Chemical Analysis of Metals[4]

E 876 Standard Practice for Use of Statistics in the Evaluation of Spectrometric Data[5]

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[2] Annual Book of ASTM Standards, Vol 11.01
[3] Annual Book of ASTM Standards, Vol 14.02
[4] Annual Book of ASTM Standards, Vol 3.05
[5] Annual Book of ASTM Standards, Vol 3.06

3. Summary of Test Method

3.1. The sample is dissolved in mixed acids. The sample solution is introduced into the plasma source of an ICP spectrometer and the intensities at selected wavelengths from the plasma emission spectrum are compared to the intensities at the same wavelengths measured with calibration solutions.

4. Significance and Use

4.1. These test methods for the chemical analysis of metals and alloys are primarily intended to test such materials for compliance with compositional specifications. It is assumed that all those who use these test methods will be trained analysts capable of performing common laboratory procedures skillfully and safely. It is expected that work will be performed in a properly equipped laboratory.

5. Apparatus

5.1. Inductively-coupled Argon Plasma (ICP) Atomic Emission Spectrometer. -- The instrument is equipped with an argon-plasma source, a sample transport system for introducing the test sample and calibration solutions into the plasma. The monochromator or polychromator must be capable of isolating the required wavelengths shown in Table 2 for measurement of their intensities by a linear photometer. Multi-element programmed analysis including automatic data acquisition and computer-controlled calibration and analysis calculations may be used if available, provided that, in addition to calculated results, the instrument records intensity readings each time a test sample or calibration solution is presented to the instrument.

NOTE -- All elements (including aluminum) are calibrated as linear functions of intensity. If the instrument cannot be set to measure aluminum and ignore other elements in calibration solutions #1 and #4, then a separate determination of aluminum must be made using calibration solutions #1, #2 and #4. The other elements can then be determined together in another run using only calibration solutions #2 and #3.

Use the calibration solutions prepared in section 10.1 under Calibration in determining the instrument settings for the elements in this matrix. Follow the manufacturer's instructions to set the wavelengths and parameters to provide as large a difference between the intensity readings for the high and low calibration concentrations as is consistent with stable instrument readings. If there is a question of linearity of the instrument's response over the range of solution concentrations given, a third standard, equidistant between the two listed standards, must be measured to verify linearity.

6. Reagents

6.1. Purity of Reagents - Unless otherwise indicated, all reagents used in this test method shall conform to the "Reagent Grade" Specifications of the American Chemical Society.[6] Other chemicals may be used provided that it is first ascertained that the reagent used is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

6.2. Purity of Water - Unless otherwise indicated, references to water shall be understood to mean reagent water as defined by Type II of Specification D 1193.

6.3. Aluminum, Standard Solution (1 mL = 20.0 mg Al) -- Transfer 2.0000 g of aluminum (purity: 99.999% min) to a 250-mL beaker. Cover, add 50 mL of HCl(1+1) and a small crystal of mercuric nitrate. Heat gently to accelerate the reaction, but avoid temperatures high enough to cause a noticeable volume loss. If the reaction slows, add more mercuric salt as needed. A number of hours may be required to complete the dissolution (only a small droplet of mercury will remain undissolved.) Transfer the solution to a 100-mL

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[6] "Reagent Chemicals, American Chemical Society Specifications," Am. Chemical Soc., Washington, DC. For suggestions on testing of Reagents not listed by the American Chemical Society, see "Reagent Chemicals and Standards," by Joseph Rosin, D. Van Nostrand Co. Inc., New York, NY, and the "United States Pharmacopeia," United States Pharmacopeial Convention, Rockville, MD.

volumetric flask, dilute to volume, and mix. Store in a polyethylene bottle.

6.4. Boric Acid Solution (3 g / 100 mL) -- Dissolve 3.0 g of boric acid (H_3BO_3) in 100 mL of boiling water.

6.5. Cadmium, Standard Solution (1 mL = 1.00 mg Cd) -- Transfer 1.000 g of cadmium (purity: 99.95% min) to a 250-mL beaker. Cover and add 40 mL of HNO_3(1+1) and 10 mL of HCl. After dissolution is complete, heat to boiling to remove oxides of nitrogen. Cool, transfer to a 1-L volumetric flask, add 240 mL of HCl, dilute to volume, and mix. Store in a polyethylene bottle.

6.6. Cerium, Standard Solution A (1 mL = 1.00 mg Ce) -- Dry ceric ammonium nitrate ($(NH_4)_2Ce(NO_3)_6$, also known as ammonium hexanitrato cerate) (purity: 99.95% min) for 4 h at 85°C and cool to room temperature in a desiccator. Dissolve 3.913 g of dry ceric ammonium nitrate in 100 mL of HCl(1+9). Transfer to a 1-L volumetric flask, add 240 mL of HCl and 20 mL of HNO_3, dilute to volume, and mix. Store in a polyethylene bottle.

6.7. Cerium, Standard Solution B (1 mL = 0.010 mg Ce) -- Using a pipet, transfer 1.00 mL of Cerium Standard Solution A to a 100-mL volumetric flask. Dilute to volume with Dilution Solution and mix.

6.8. Dilution Solution -- Half fill a 2-L volumetric flask with water. Add 500 mL of HCl and 40 mL of HNO_3, swirl to mix, dilute to the mark, and mix.

6.9. Iron, Standard Solution A (1 mL = 1.00 mg Fe) -- Transfer 1.000 g of iron (purity: 99.95% min) to a 250-mL beaker, cover, and add 100 mL of HCl(1+1). Boil gently to complete dissolution. Cool and transfer to a 1-L volumetric flask, add 200 mL of HCl and 20 mL of HNO_3, dilute to volume, and mix. Store in a polyethylene bottle.

6.10. Iron, Standard Solution B (1 mL = 0.010 mg Fe) -- Using a pipet, transfer 1.00 mL of Iron Standard Solution A to a 100-mL volumetric flask. Dilute to volume with Dilution Solution and mix.

6.11. Lanthanum, Standard Solution A (1 mL = 0.010 mg La) -- Ignite lanthanum oxide (La_2O_3) (purity: 99.9% min) for 1 h at 1000°C and cool to room temperature in a desiccator. Dissolve 1.173 g of dry lanthanum oxide in 100 mL of HCl-(1+9) and transfer to a 1-L volumetric flask. Add 240 mL of HCl and 20 mL of HNO_3, dilute to volume, and mix. Store in a polyethylene bottle.

6.12. Lanthanum, Standard Solution B (1 mL = 0.010 mg La) -- Using a pipet, transfer 1.00 mL of Lanthanum Standard Solution A to a 100-mL volumetric flask. Dilute to volume with Dilution Solution and mix.

6.13. Lead, Standard Solution (1 mL = 1.00 mg Pb) -- Transfer 1.000 g of lead (purity: 99.9 min) to a 250-mL beaker, cover, and add 40 mL of HNO_3(1+1). boil gently to complete dissolution and to remove oxides of nitrogen. Cool, transfer to a 1-L volumetric flask, add 250 mL of HCl, dilute to volume, and mix. Store in a polyethylene bottle.

6.14. Zinc Matrix Solution (50 mL = 3.75 g Zinc Matrix Standard) -- Transfer 18.75 g ± 0.10 g of Zinc Matrix Standard to a 250-mL plastic beaker. Cover and add about 50 mL of water. Add 62.5 mL of HCl and heat enough to maintain the reaction but not enough to evaporate the solution. When most of the material has dissolved, add 5.0 mL of HNO_3. When all solids have dissolved, remove from the heat and allow to cool. Transfer to a 250-mL plastic volumetric flask, dilute to the mark, and mix.

6.15. Zinc Matrix Standard -- Use a zinc reference material[1] of known composition with respect to the elements listed in the scope of this method. (SRM 728, Intermediate Purity Zinc, available from The Office of Standard Reference Materials, National Institute of Standards and Technology, Gaithersburg, MD 20899, has been found suitable.)

7. Sampling

7.1. For procedures for sampling the material, refer to practices E 55 and E 88.

8. Interlaboratory Studies and Rounding of Calculated Values

8.1. Only four laboratories were available to test this method, therefore, the interlaboratory test does not comply with the protocol for Practice E 173. However, the statistics were calculated according to Practice E 173.

8.2. Calculated values shall be rounded to the desired number of places as directed in 3.4 to 3.6 of Recommended Practice E 29.

9. Hazards

9.1. For precautions to be observed in the use of certain reagents in this method, refer to Practices E 50.

10. Calibration

10.1. Prepare calibration and test sample solutions before calibration measurements are started.

10.2. Calibration Solutions -- All calibration solutions contain the same concentration of zinc as the test sample solutions. The aluminum content of calibration solutions #2 and #3 must be equal to the mid-point of the calibrated aluminum range. Using a pipet, transfer 50.0 mL of the Zinc Matrix Solution into each of 4 100-mL plastic volumetric flasks marked Cal#1 through Cal#4. Add the volumes of standard solutions specified in the table below, dilute to volume with Dilution Solution, and mix:

Standard Solution Volumes Added (mL)

(Use standard solution A or B as indicated in parentheses.)

Element	#1	#2	#3	#4
aluminum	6.00	11.0	11.0[a]	16.0
cadmium	----	----	1.00	----
cerium	----	2.00(B)	4.00(A)	----
iron	----	1.00(B)	4.00(A)	----
lanthanum	----	2.00(B)	4.00(A)	----
lead	----	----	1.00	----

[a]Added to match solution #2, not for calibration purposes.

Solution Concentrations Added (mg/L)[a]

Element	#1	#2	#3	#4
aluminum	1200	2200	----	3200
cadmium	----	----	10.0	----
cerium	----	0.2	40.0	----
iron	----	0.1	40.0	----
lanthanum	----	0.2	40.0	----
lead	----	----	10.0	----

[a]The Concentration Table (Table 3) is derived from this table by adding the trace element contributions from the Zinc Matrix Solution to the concentrations shown in this table and converting the resulting sum to weight %.

10.3. Test Sample Solution -- Transfer a 3.8 to 4.2-g portion of the test sample weighed to the nearest 0.02 g to a 250-mL polytetrafluoroethylene beaker. Add about 30 mL of water, cover, and cautiously add 25 mL of HCl in increments. Heat gently to maintain the reaction, if necessary, but do not boil. When most of the material has dissolved, add 2.0 mL of HNO_3, let the solution cool for about 20 minutes, transfer to a 100-mL plastic volumetric flask, dilute to volume, and mix.

10.4. Automatic Calibration Mode -- (If the instrument does not have the capability to take data from calibration solutions and calculate and store the equations needed to convert instrument readings from test samples directly into concentration values automatically, or if that capability is not to be used, proceed in accordance with Non-automatic Mode below.) Set up the instrument parameters as directed in Preparation of Apparatus. If one of the parameters is a "lower limit" (used to establish a printed "less than" value), set it to 0 for each element. Enter the concentrations of the elements to be found in each calibration solution. Table 3 gives the concentration table for solutions based upon NBS SRM 728 as Zinc Matrix Standard. If a different Zinc Matrix Standard is used, Table 3 must be revised to reflect the different composition of that material. Using the calibration solutions, follow the manufacturer's procedure to perform the instrument calibration at the wavelengths specified in Table 2. Without undue delay, proceed in accordance with Automatic Mode in the Procedure section.

10.5. Non-automatic Mode -- No separate calibration run is required if intensity readings only are recorded. Set up the instrument to measure intensities at the wavelengths specified in Table 2 according to the manufacturer's instructions and proceed to Non-automatic Mode in the Procedure section.

11. Procedure

11.1. Measurement Sequences -- To reduce the distortion of data if instrument drift occurs while measurements are taken, solutions are presented to the instrument in a specified order and only a single reading (or, if desired, the average of several integrations) is recorded each time a solution is presented to the instrument. Repeat the following sequence of solution presentations 4 times to obtain the required 4 replicate readings: calibration solution #1, calibration solution #2, test sample solution, calibration solution #3, and calibration solution #4. More than 1 test sample solution may be presented to the instrument between calibration solutions #2 and #3. Many instruments do not require a rinse between each solution presentation, but it is advisable to rinse the system periodically. A rinse with Dilution Solution after each completed sequence is the minimum recommended frequency.

11.2. Automatic Mode -- Calibrate the instrument in accordance with Automatic Calibration Mode in the Calibration section. Without undue delay, proceed to analyze the solutions as directed in Measurement Sequences above. CAUTION: Attempting to shorten the measurement time by substituting 4 readings taken during a single solution presentation instead of the prescribed sequences may lead to an improper calibration even though the precision of the measurements appears satisfactory. Be sure that the instrument has been set to record intensities as well as concentrations for both calibration and test solutions. Proceed in accordance with Automatic Mode in the Calculations section.

11.3. Non-automatic Mode -- With the instrument set up according to Preparation of Apparatus, measure the calibration and test sample solutions as directed in Measurement Sequence above, recording the intensity readings for each solution presentation. Solution presentation may be performed manually or, if the instrument is provided with the necessary equipment, by automatic solution presentation. The proper sequencing of the replicate readings must be followed in either case. Proceed in accordance with Non-automatic Mode in the Calculation section.

12. Calculations

12.1. Automatic Mode -- The instrument record includes calibration and test solution results in both intensity and concentration units. To test the accuracy of the recorded concentrations, calculate the average concentrations of the sample and the appropriate calibration solutions. For each calibration solution, determine the difference between the average recorded concentration and the value listed in the concentration table. The automatically calculated concentration values are acceptable if the differences are less than 5% (relative) for the high and 10% (relative) for the low calibration solution. The requirement for aluminum is that the average error for the three calibration results must be within 2% (relative). If the results for an element meet these criteria, record the average test sample concentration (C_s), and proceed in accordance with the Report section. Otherwise, use the intensity readings for the element to calculate results as directed in Non-automatic Mode below.

12.2. Non-automatic Mode -- The measurement data consists of 4 intensity readings for each calibration and test sample solution. Calculate the average intensity values for the high calibration solution (R_h), the low calibration solution

(R_l), and the test sample solution (R_s). For aluminum, also determine the average intensity (R_m) for the middle calibration solution. Determine the test sample concentration as directed in either <u>Graphical Calibration</u> or <u>Calculator Calibration</u> below.

12.3. <u>Graphical Calibration</u> -- Plot R_h and R_l (also R_m for aluminum) as the y-variable (measured along the vertical axis) against the corresponding concentrations from the concentration table as the x-variable (horizontal axis). Draw the calibration curve, a line which (except for aluminum) extends through both points back to intersect the vertical axis. For aluminum, the calibration curve is a straight line plotted from the concentration value for the low calibration solution to the concentration value of the high calibration solution in such a manner that the positive and negative differences between the line and all points is minimized. Note that no calibration curve can be extended above the concentration of its high end. In addition, the aluminum curve cannot be used for concentrations below its low end. The concentration of the test sample (C_s) is read from the x-axis corresponding to the intersection of the average sample reading (R_s) with the calibration curve. (For aluminum, proceed in accordance with the Report section.)In the same manner, read the concentrations corresponding to the lowest and highest intensity readings for the low calibration solution (C_l and C_h, respectively.) Record the values of C_s, C_l, and C_h. Proceed in accordance with the Report section.

12.4. <u>Calculator Calibration</u> -- Use a calculator or computer least-squares curve fit program that also calculates predicted values for x and y from given values of the other variable. Enter the intensity readings for calibration solutions as the y-variable with concentrations from the concentration table as the associated x-values. Enter the average intensity reading of the test sample solution and use the program to predict its concentration (C_s). (For aluminum, proceed in accordance with the Report section.)

In the same manner, calculate the concentrations corresponding to the lowest and highest intensity readings for the low calibration solution (C_l and C_h, respectively.) Record the values of C_s, C_l, and C_h. Proceed as directed in the Report section.

? 6.2

12.5. Determination Limit (DL) -- is calculated according to Practice E-876 Section 6.3 For this application it is defined as the concentration below which the relative error of the calculated concentration is predicted to be greater than 15% at the 95% confidence level. The DL concept does not apply to the aluminum determination because the calibration curve for that element does not extend lower than approximately 3% aluminum. For all other elements, the DL establishes the lowest practical concentration that can be reported by the use of this method. The method specifies 4 replicate readings for both calibration and sample solutions. Use the standard deviation of the low calibration solution readings to calculate the DL:

$DL = 10.6 \times s$ where: s = the standard deviation.

12.6. Test sample concentration, (C) -- Calculate by correcting for the sample weight if different from 4.00 g:

$C = C_s \times (4/A)$,

where: C_s = the average recorded test sample concentration

A = the test sample weight in grams.

13. Report

13.1. Report the aluminum content as C% Al if the calculated value falls within the range of 3.0% to 8.0%. Otherwise, do not report the results for aluminum or any other element because the test sample is not within the scope of this method. For each other element, calculate the DL as directed in Determination Limit (DL) in the Calculations section. Compare the DL with the lower scope limit and use the greater of the two as the lower reporting limit (LRL). If the calculated concentration, C, of the element is less than the value of LRL, report the concentration of the element as "less than" LRL. If C is greater than the value of LRL, report the element concentration as C% Element. CAUTION:

Do not report any element whose concentration is more than 10% (relative) higher than the high calibration concentration for that element.

14. Precision and Bias

14.1. Precision calculations have been done according to Standard Practice E 173. The results are summarized below.

Table 1 Statistical Information

Element	Sample	#Labs	Mean	R_1	R_2
Aluminum	Gal-5	4	4.88	0.139	0.273
	Gal-6	4	5.31	0.097	0.319
	Gal-7	4	6.93	0.384	0.582
Cadmium	Gal-5	4	0.00020	0.00012	0.00016
	Gal-6	4	0.00006	0.00001	0.00014
	Gal-7	4	0.0109	0.00067	0.00082
Cerium	Gal-5	4	0.0235	0.0015	0.0026
	Gal-6	4	0.0399	0.0022	0.0031
	Gal-7	4	0.0306	0.0021	0.0020
Iron	Gal-5	4	0.0040	0.00054	0.00076
	Gal-6	4	0.0274	0.0057	0.0114
	Gal-7	4	0.0291	0.0047	0.0074
Lanthanum	Gal-5	4	0.0299	0.0018	0.0044
	Gal-6	4	0.0664	0.0039	0.0050
	Gal-7	4	0.0339	0.0026	0.0072
Lead	Gal-5	3	0.0047	0.00095	0.00090
	Gal-6	3	0.0013	0.0013	0.0012
	Gal-7	3	0.0062	0.00089	0.0011

14.2. Bias - The bias of this method could not be evaluated because adequate certified standard reference materials were unavailable at the time of testing. The user is cautioned to verify by the use of certified reference materials, if available, that the accuracy of this method is adequate for the contemplated use.

Table 2. Wavelengths and Instrument Conditions.

Elem	Wavelength	Time	#Integ	BCor1	BCor2
Al	3092.7	1.0	3	-	-
Cd	2265.02	.5	3	2264.46	2265.58
Ce	4186.6	.5	2	-	-
Fe	2599.4	.5	2	-	-
La	3988.5	.5	2	3987.54	3989.06
Pb	2832.97	1.0	3	-	2833.36

Note: The tabulated conditions were those found satisfactory on one instrument. Wavelengths are expressed in angstroms. Time = seconds for each integration, #Integ = number of integrations averaged for each reading, and BCor1 and BCor2 are off-peak background correction wavelengths.

Table 3. Concentration Table for Calibration Solutions.[a]

(The values in this table assume SRM 728 as Zinc Matrix, a sample weight of 4.00 g, and results reported in %.)

Element	#1	#2	#3	#4
aluminum	3.00	5.50	--	8.00
cadmium	--	.00011	.0251	--
cerium	--	.00050	.1000	--
iron	--	.00052	.1003	--
lanthanum	--	.00050	.1000	--
lead	--	.00104	.0260	--

[a]To calculate the concentration table for a different Zinc Matrix material, add the ppm contributed from 3.75 g of that material in a volume of 100 mL to the ppm shown in the Concentrations Added table shown in the Calibration section. Calculate the % element by dividing the ppm by 400.

Designation: A 755/A 755M – 89

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Standard Specification for Steel Sheet, Metallic Coated by the Hot-Dip Process and Prepainted by the Coil-Coating Process for Exterior Exposed Building Products[1]

This standard is issued under the fixed designation A 755/A 755M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

1. Scope

1.1 This specification covers steel sheet metallic coated by the hot-dip process and coil-coated with organic films for exterior exposed building products of various qualities. Sheet of this designation is furnished in coils, cut lengths, and formed cut lengths. Building products include corrugated and various types of roll and brake-formed configurations.

1.2 Substrate supplied under this specification shall meet the applicable requirements of the latest issue of Specifications A 446/A 446M (Galvanize, Structural Quality), A 463 (Aluminum-Coated), A 526/A 526M (Galvanize, CQ), A 527/A 527M (Galvanize, LFQ), A 528/A 528M (Galvanize, DQ), A 642/A 642M (Galvanize, DQSK), A 792 [A 792M] (Aluminum-Zinc Alloy-Coated), or A 875/A 875M (Zinc-5 % Aluminum-Mischmetal Alloy-Coated) depending on the requirements of the purchaser.

1.3 Coating systems supplied under this specification shall consist generally of a primer coat covered by various types and thicknesses of top coats. The combination of primer and top coat is usually classed as either a two-coat thin-film system or as a two-coat (or more) thick-film system. Typical top coats are: polyester, silicone polyester, acrylic, fluoropolymer, plastisol, or polyurethane.

1.4 This specification is applicable to orders in either inch-pound units (as A 755) or acceptable SI units [as A 755M]. Inch-pound units and SI units are not necessarily equivalent. Within the text, SI units are shown in brackets. Each system shall be used independently of each other.

2. Referenced Documents

2.1 *ASTM Standards:*

A 446/A 446M Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Structural Quality[2]

A 463 Specification for Steel Sheet, Cold Rolled, Aluminum-Coated, Type 1 and Type 2[2]

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

A 525M Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process [Metric][2]

A 526/A 526M Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Commercial Quality[2]

A 527/A 527M Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Lock-Forming Quality[2]

A 528/A 528M Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Drawing Quality[2]

A 642/A 642M Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Drawing Quality, Special Killed[2]

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

A 792 Specification for Steel Sheet, Aluminum-Zinc Alloy-Coated by the Hot-Dip Process, General Requirements[2]

A 792M Specification for Steel Sheet, Aluminum-Zinc Alloy-Coated by the Hot-Dip Process, General Requirements [Metric][2]

A 875/A 875M Specification for Steel Sheet, Zinc-5 % Aluminum-Mischmetal Alloy-Coated by the Hot-Dip Process[2]

B 117 Method for Salt Spray (Fog) Testing[4]

D 522 Test Method for Mandrel Bend Test of Attached Organic Coatings[5]

D 523 Test Method for Specular Gloss[5]

D 659 Method of Evaluating Degree of Chalking of Exterior Paints[5]

D 714 Method of Evaluating Degree of Blistering of Paints[5]

D 822 Practice for Operating Light and Water Exposure Apparatus (Carbon-Arc Type) for Testing Paint, Varnish, Lacquer, and Related Products[5]

D 870 Practice for Testing Water Resistance of Coatings Using Water Immersion[5]

D 1654 Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments[5]

D 1735 Practice for Testing Water Resistance of Coatings Using Water Fog Apparatus[5]

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

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[2] *Annual Book of ASTM Standards*, Vol 01.06.

[3] *Annual Book of ASTM Standards*, Vol 01.05.

[4] *Annual Book of ASTM Standards*, Vol 03.02.

[5] *Annual Book of ASTM Standards*, Vol 06.01.

D 2244 Method for Calculation of Color Differences from Instrumentally Measured Color Coordinates[5]

D 2247 Practice for Testing Water Resistance of Coatings in 100 % Relative Humidity[5]

D 3363 Test Method for Film Hardness by Pencil Test[5]

2.1 *U.S. Military Standards:*

MIL-STD-129 Marking for Shipment and Storage[6]

MIL-STD-163 Steel Mill Products, Preparation for Shipment and Storage[6]

2.3 *U.S. Federal Standard:*

Fed. Std. No. 123 Marking for Shipments (Civil Agencies)[6]

2.4 *National Coil Coaters Association (NCCA) Standards:*

NCCA II-4 Best Method for Measurement of Dry Film Thickness of Paint, Varnish, Lacquer, and Related Products—Film Thickness of 0.3 Mil or Greater[7]

NCCA II-10 Specification for Measurement of Adhesion and Flexibility by the Wedge Bend[7]

NCCA II-12 Specification for Determination of Relative Pencil Hardness[7]

NCCA II-13 Specification for Microscopic Determination of Coating Thickness[7]

NCCA II-18 Specification for Evaluation of Solvent Resistance by Solvent Rub Test[7]

NCCA II-19 Standard "T" Bend Test Method[7]

NCCA II-23 Test Method for Determination of Adhesion and Flexibility by the Draw Method[7]

NCCA III-1 Standard Method for Water Immersion Test of Organic Coatings on Metallic Surfaces[7]

NCAA III-2 Standard Method of Salt Spray (Fog) Testing[7]

NCCA III-3 Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments[7]

NCCA III-4 A Standard Method for Water Fog Testing of Organic Coatings[7]

NCCA III-6 Standard Method for Condensation-Humidity Testing of Organic Coatings on Metallic Surfaces[7]

NCCA III-7 Standard Method for "Dew-Cycle" Accelerated Weatherometer Testing[7]

NCCA III-8 Standard Method for Measuring Chalk Resistance of Exterior Coil Coatings[7]

3. Terminology

3.1 *Definitions:*

3.1.1 *Substrate:*

3.1.1.1 *commercial quality (CQ)*—steel sheet intended for applications where the product is subjected to bending or moderate forming.

3.1.1.2 *lock-forming quality (LFQ)*—steel sheet intended for applications where the product is subjected to machine lock forming. The high speed forming by the machines imposes requirements on both the base metal and the coating which are in excess of the formability requirements of commercial quality.

3.1.1.3 *drawing quality (DQ)*—steel sheet intended for fabrication of parts where drawing or severe forming may be involved.

3.1.1.4 *drawing quality, special killed (DQSK)*—steel sheet intended for fabrication of an identified part where particularily severe drawing or forming may be involved or essential freedom from aging is required.

3.1.1.5 *structural quality (SQ)*—steel sheet intended for applications where mechanical properties are specified. Such properties or values include those indicated by tensile, hardness, or other commonly accepted mechanical tests.

3.1.2 *Coatings:*

3.1.2.1 *acrylic*—a polymer based on resins prepared from a combination of acrylic and methacrylic esters, acrylic and methacrylic acids, and styrene. They contain one or more functional groups such as amide, hydroxy, or carboxy and form thermosetting systems on baking by cross-linking with themselves, or amino or epoxy resins.

3.1.2.2 *conversion coating*—a chemical treatment, normally applied to a metal surface prior to final finishing, which is designed to react with and modify the metal to produce a surface suitable for painting.

3.1.2.3 *epoxy—polymers based on epoxy resins*— usually the reaction product of epichlorohydrin and biphenol-A and are generally cross-linked with amino or urea-formaldehyde resins to form thermosetting systems on baking.

3.1.2.4 *fluorocarbon*—polymers based on fluorocarbon resins made by the polymerization of vinyl fluoride monomer (PVF) or vinylidene fluoride monomer (PVF2). These resins are usually formulated into coatings by dispersion of finely divided particles in dispersents and diluents and form thermosetting systems on baking.

3.1.2.5 *plastisol*—a dispersion of finely divided vinyl resin in plasticizers. During the baking process, the resin particles are solvated by the plasticizer and fuse into a continuous film.

3.1.2.6 *polyester*—a polymer based on the condensation products of polybasic acids and diols (dihydric alcohols), sometimes called oil-alkyds. They may be modified by the addition reaction of other monomers such as styrene or acrylic esters. Polyester resins are generally cross-linked with amino resins to form thermosetting systems on baking.

3.1.2.7 *polyurethane*—a polymer produced by the addition reaction of an acrylic polyol or polyester polyol with an isocyanate-containing compound to produce thermosetting systems on baking.

3.1.2.8 *primer*—the first complete layer of paint of a coating system applied to an uncoated surface. The type of primer varies with the type of surface and its condition, the intended purpose, and the coating system being used.

3.1.2.9 *silicone polyester*—a polymer which is the reaction product between an organo-siloxane intermediate and an alkyd resin, or a cold blend of a silicone resin and a compatible alkyd resin. These resins are generally cross-linked with amino resins to form thermosetting systems on baking.

3.1.3 *Coating Characteristics:*

3.1.3.1 *chalking*—the formation on a pigmented coating of a friable powder evolved from the film itself at or just beneath the surface.

3.1.3.2 *fade*—a loss in color intensity experienced by pigmented organic coatings over time, generally due to the effect of ultraviolet radiation.

3.1.3.3 *gloss*—the luster, shininess or reflecting ability of a surface.

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

[7] Available from the National Coil Coaters Association, 1900 Arch St., Philadelphia, PA 19103.

3.2 *Descriptions of Terms Specific to This Standard:*

3.2.1 *bottom side*—the side of prepainted sheet opposite the exposed weathering side, generally coated with a washcoat (see 3.2.6) but sometimes coated with the same system as the top side.

3.2.2 *coil coating*—a continuous process by which paint and other coatings are applied and baked onto a moving strip of steel sheet. Generally, rolls are used to pick-up, meter, and deposit the liquid coating onto the moving strip and are also used to support the strip through the line. The product of this process is called prepainted steel sheet.

3.2.2 *mil*—a unit for measuring thickness. One mil = 0.001 inch [0.025 mm]. This term is generally applied only to paint films.

3.2.3 *paint*—in terms of coil coating, an organic liquid, generally pigmented, which is converted to a solid film by baking.

3.2.4 *roll former*—an apparatus that forms a continuous strip of painted metal into various shapes by a series of contoured steel rolls.

3.2.5 *top side*—the side of the prepainted sheet which is exposed to weathering. The organic coating on the top side typically consists of a primer and a topcoat.

3.2.6 *washcoat*—a thin organic coating, usually a polyester, applied to the back or unexposed side of prepainted sheet (also known as a backercoat). This coating may or may not be pigmented and is applied for such reasons as protection of the topcoat while in coil form, interior appearance, and lubrication during roll forming.

4. Classification

4.1 The substrate shall conform to all requirements of the appropriate specification for the quality ordered as follows:

4.1.1 *Zinc-Coated (Galvanized):*

4.1.1.1 *CQ*—Specification A 526/A 526M.

4.1.1.2 *LFQ*—Specification A 527/A 527M.

4.1.1.3 *DQ*—Specification A 528/A 528M.

4.1.1.4 *DQSK*—Specification A 642/A 642M.

4.1.1.5 *SQ*—Specification A 446/A 446M.

4.1.2 *Aluminum-Coated:*

4.1.2.1 Specification A 463.

4.1.3 *Aluminum-Zinc Alloy-Coated:*

4.1.3.1 Specification A 792 [A 792M].

4.1.4 *Zinc-5 % Aluminum-Mischmetal Alloy-Coated:*

4.1.4.1 Specification A 875/A 875M.

4.2 The organic coating shall typically consist of a primer and a topcoat on the top (exposed) side and washcoat on the bottom (unexposed) side. Typical primers and topcoats are as follows:

4.2.1 *Primers:*

4.2.1.1 Epoxy.

4.2.1.2 Acrylic.

4.2.1.3 Polyurethane.

4.2.2 *Top coats:*

4.2.2.1 Polyester.

4.2.2.2 Silicone polyester.

4.2.2.3 Acrylic.

4.2.2.4 Fluoropolymer.

4.2.2.5 Plastisol.

4.2.2.6 Polyurethane.

4.2.3 *Washcoats or backercoats:*

4.2.3.1 Polyester.

4.2.3.2 Acrylic.

4.3 Other coatings may be specified if agreed upon betwen producer and purchaser (see Note 2).

5. Ordering Information

5.1 The coated flat sheet covered by this specification is produced on continuous lines to decimal thickness only. The thickness of the sheet includes the base steel and the metallic coating. The thickness of the organic system is in addition to the substrate (base steel and metallic coating).

5.2 Orders for material under this specification should include the following information, as applicable, to describe the required product adequately:

5.2.1 Product name (prepainted steel sheet),

5.2.2 ASTM designation number,

5.2.3 ASTM designation of substrate (see 4.1),

5.2.4 Metallic coating type (see 4.1),

5.2.5 Metallic coating weight [mass] designation,

5.2.6 Metallic coating finish (such as regular, minimized spangle, extra smooth, or minimized spangle-extra smooth),

5.2.7 Organic coating system designation (see 4.2 or 4.3),

5.2.8 Dry organic film thickness top side and bottom side (the top side typically consists of a primer and topcoat and the bottom side a primer and a washcoat; however the bottom side may be ordered to the same quality as the topside) (see 7.4.2),

5.2.9 Protection required (waxed or strippable coating),

5.2.10 Dimensions (thickness, width, either flat or formed (overall or cover) and length (if cut length)) and, if applicable, type of formed configuration,

5.2.11 Coil size requirement: maximum outside diameter, acceptable inside diameter, and maximum weight [mass],

5.2.12 Cut length requirement: maximum lift weight [mass],

5.2.13 Special requirements, if any, and

5.2.14 Application (part identification and description).

NOTE 1—A typical ordering description is as follows:

Prepainted Steel Sheet, ASTM A 755 - ____, Zinc Coated (Galvanized), ASTM A 446 - ____, Grade ____, G 90, Extra Smooth, Top Side Primer, 0.25 mil thickness plus Gold Silicone-Polyester, 0.8 mil thickness, Bottom Side Primer, 0.25 mil thickness plus Washcoat, 0.3 mil thickness, 0.019 in. min thickness by 42 in. width by Coil, 24 in. inside diameter, 52 in. max outside diameter, 20 000 pound max weight coil for roll-formed exterior building siding.

[Prepainted Steel Sheet, ASTM A 755M - ____, Aluminum-Zinc Alloy-Coated, A 792M - ____, Commercial Quality, AZ180, Extra Smooth, Top Side Primer, 0.006 mm thickness plus White Fluoropolymer, 0.020 mm thickness, Bottom Side Primer, 0.006 mm thickness plus Washcoat, 0.008 mm thickness, 0.80 mm thickness by 1000 mm width by Coil, 600 mm inside diameter, 1320 mm max outside diameter, 4500 kg max coil for roll-formed exterior siding.]

NOTE 2—When specifying the organic coating system designation, instead of using the generic terms listed in Section 4.2, it is permissible to use trade name terminology as published by various coating and prepainted sheet suppliers. These trade name coatings are generally brand name versions of the generic coatings listed in 4.2 and usually include a primer and film thickness values.

6. Substrate Requirements

6.1 For the purposes of this specification, substrate refers to the steel sheet and metallic coating. The specific requirements for the substrate are contained in the listed referenced specifications.

7. Organic Coating Requirements

7.1 The application of organic coatings on a continuous coil coating line usually involves three major steps. These are: the application of a conversion coating, the application of a primer, and the application of one or more topcoats.

7.2 *Conversion Coating*—A conversion coating is a chemical treatment applied to the metal prior to application of the primer. It is designed to react with and modify the metal surface to enable chemical bonding to occur between the metal and the primer thus optimizing adhesion and corrosion resistance.

7.3 *Primer:*

7.3.1 The purpose of the primer is to serve as the bond between the substrate and the topcoat and to offer added corrosion protection for the entire system. For building products, primer thickness is typically 0.2 mil [0.005 mm] (tolerance ±0.05 mil [0.001 mm]). High performance primers with films as thick as 3 mils [0.075 mm] (tolerance ±0.30 mil [0.008 mm]) may be specified.

7.3.2 When a primer is used it must be compatible with both the conversion coating and the topcoat in order to ensure optimum properties of the coating system. For this reason the primer is usually not specified by the purchaser but is generally selected by the coating supplier or prepainted sheet producer for optimum compatibility.

7.3.3 See 4.2.1 for examples of typical primers.

7.4 *Topcoat:*

7.4.1 The topcoat provides color and durability and also acts as protection against atmospheric corrosion. Different topcoats are selected based on the performance or appearance requirements desired. For building products, topcoat thickness is typically 0.8 mil [0.020 mm] (tolerance ± 0.2 mil [0.005 mm]). High performance topcoats with films as thick as 12 mils [0.30 mm] (tolerance ± 1.2 mil [0.03 mm]) may be specified. Other upgraded systems may specify the application of two or more layers of topcoats.

7.4.2 The topcoat is normally applied only to the top (exposed) side of the sheet; however the bottom (unexposed) side may be ordered with the same coating as the top side. Usually the coating that is applied to the bottom side is a washcoat or backercoat (refer to 7.5).

7.4.3 See 4.2.2 for examples of typical topcoats.

7.4.4 The selection of a topcoat depends on the performance parameters required such as chalk and fade, plus the corrosion resistance needed, which must take into account the severity of the service environment.

7.5 *Washcoat or Backercoat:*

7.5.1 The washcoat or backercoat is applied to the bottom (unexposed) side of the sheet and may be pigmented or clear. Its purpose is to provide protection against damage to the top side coating during shipment and storage and also to provide some additional durability to the unexposed side during the service life of the product. For building products, washcoat thickness is typically 0.3 mil [0.008 mm] (tolerance ± 0.05 mil [0.001 mm]).

7.5.2 See 4.2.3 for examples of typical washcoats.

7.6 *Testing Requirements*—The properties of the substrate and the organic coating system, combined with the method of forming, determine the life expectancy and general appearance of the final product. Each coating system has different qualities in regard to gloss, flexibility, fading, chalking, resistance to cracking at bends, abrasion resistance, dirt retention, and resistance to varying atmospheric conditions. All of these factors should be considered in any end application. The test methods used to measure some of these parameters are listed in Annex A1 and are normally considered to be mandatory requirements. The test methods listed in Appendix X1 are used to measure other parameters but are generally considered to be nonmandatory requirements. The specific requirements for each system must be agreed upon between the producer and the purchaser.

8. Packaging, Marking, and Loading

8.1 It is common practice to use the methods of packaging as listed in the latest revision of Practices A 700. Coils should be shipped eye vertical to minimize transit abrasion. Roll-formed panels may require special packaging. Coil-coated steel is finished material and should be treated as such in handling and storage.

8.2 The purchaser may specify methods other than those listed in 8.1.

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

8.4 Proper on-site storage of building panels prior to erection has been found to be important in maintaining the integrity of the coating system. Corrosion failure can result when building panels are not properly protected from water being trapped during storage prior to installation. Pallets should be placed off the ground and at a slight angle for effective drainage. In addition, the use of metal covers or the equivalent is an effective way of keeping pallets dry. Plastic bags should not be used to protect the coils or pallets.

9. Inspection

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

9.2 *Responsibility for Inspection*—Unless otherwise specified in the contract or purchase order, the producer is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the producer may use any facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the purchaser. The purchaser reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure that supplies and services conform to prescribed requirements.

10. Rejection and Rehearing

10.1 Unless otherwise specified, any rejection should be reported to the producer within a reasonable time after receipt of the product by the purchaser.

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

10.3 Samples that are representative of the rejected product shall be made available to the producer. In the event that the producer is dissatisfied with the rejection, a rehearing may be requested.

ANNEX

(Mandatory Information)

ANNEX A1. ASTM AND NCCA METHODS FOR TESTING PHYSICAL AND MECHANICAL PROPERTIES OF COIL COATINGS

A1.1 Requirements for physical and mechanical tests which are mandatory at the time of production are as follows:

Test	ASTM Standard	NCCA Standard[7]
Elongation of Attached Coating	D 522	NCCA II-23
Gloss	D 523	...
Color	D 2244	...
Pencil Hardness	D 3363	NCCA II-12
Dry Film Thickness	...	NCCA II-4 or II-13
Cure	...	NCCA II-18
T-Bend	...	NCCA II-19
Wedge Bend	...	NCCA II-10

APPENDIX

(Nonmandatory Information)

APPENDIX X1. ASTM AND NCCA METHODS FOR TESTING THE PERFORMANCE OF COIL COATINGS

X1.1 Tests for the performance evaluation of coil coatings which are not necessarily mandatory at the time of coating:

Test	ASTM Standard	NCCA Standard[7]
Degree of Blistering	D 714	...
Chalk Resistance	...	NCCA III-8
Salt Spray	D 117	NCCA III-2
Weatherometer	D 659	NCCA III-7
Artificial Weathering	D 822	...
Water Immersion	D 870	NCCA III-1
Water Fog	D 1735	NCCA III-4
Humidity	D 2247	NCCA III-6
Painted Specimens Subjected to Corrosive Environments	D 1654	NCCA III-3

the department for Enterprise

STANDARDS action plan for business

EUROPE OPEN FOR BUSINESS

Standards - a key to business success in the Single Market

Why?

Using common European standards will often be the best way for businesses to satisfy the common regulations – to promote safety, for example – that will apply to wide ranges of products when they are sold anywhere in the Single Market.

All Member States of the Community impose a wide range of legal obligations on business in the interests of safety, consumer protection and the like. However well justified, they give rise to technical barriers to trade because of differing requirements and procedures in different Member States.

The traditional solution of a Directive setting out the detailed requirements a product must satisfy in order to be entitled to be sold freely throughout the Community proved a slow process. So, in May 1985, the Council of Ministers decided on a **"New Approach to Technical Harmonisation and Standards"**.

Under this "New Approach", Directives will set out **"essential requirements"** relating to safety and so on, written in general terms, which must be satisfied before products may be sold anywhere in the Community. European standards will be the main way that businesses demonstrate that these "essential requirements" have been satisfied. **All products must satisfy the "essential requirements" – even if there is no intention that they should be sold across national boundaries**.

European standards will increasingly be used for public procurement, which accounts for about 15% of the Community's gross domestic product.

All companies in the Community should have a fair chance in seeking public contracts. The long-standing "Supplies" and "Works" Directives, which apply to governments and local authorities, sought to ensure that public contracts are advertised and to limit the use of "single" tendering, but the position remained less than fair. The "Supplies" Directive has recently been amended to incorporate, among other things, a requirement (with limited exceptions) to use European standards where they exist. The "Works" Directive is likely to be similarly amended.

The European Commission has proposed Directives which would go beyond central and local government, to cover the transport, energy, water and telecommunications sectors - the so-called "excluded sectors".

Competition in the Single Market will become more intense, in the United Kingdom as well as elsewhere in the Community. Standards provide the foundation for quality: and quality is the route to satisfied customers and success in business.

Standards provide the foundation for quality. They influence every aspect of production from design to delivery and after-sales service. The benefits include easier design and manufacture through standard components; more efficient, cost effective and easily maintained production systems; and greater customer confidence in the product and in the producer.

Quality is the route to satisfied customers. Quality means good design; efficient production; and reliable products and services. Quality means giving the customer a product which is fit for its purpose and appropriate to his or her needs. Quality in production means reduced waste and reworking; and streamlined systems, all of which reduce overheads. Quality means profits by satisfying customers, by "doing it right first time, every time".

When?

Many decisions about "New Approach" Directives and European standards have already been taken; more will be taken month by month. These decisions will come into effect progressively over the period up to 1992. The Single Market is inevitable - and it is being created NOW.

So, to succeed in the Single Market, you need to prepare and implement:

a standards action plan for your business

Investigate

To plan effectively, you first need information – information that is relevant to your business both as it is now and as you intend it to develop in the Single Market – see pages 10–11 for useful sources of information.

SOME KEY QUESTIONS

On safety regulations

- ☐ Which "New Approach" Directives (see pages 7-9) will affect your business?
- ☐ Which standards will you use so that your products satisfy the "essential requirements"?
- ☐ What procedures do you have to follow under those Directives for your products to be sold freely throughout the Community?
- ☐ Have those Directives and standards been agreed? If not, what stage have they reached? When will they come into effect?

On public procurement

- ☐ Do you, or will you, have important customers in central or local government; or in the transport, energy, water or telecommunications sectors?
- ☐ How will Directives affect their purchasing practices?

On satisfying customers

- ☐ How will existing customers respond to your using European standards?
- ☐ How can using European standards help you win new customers?

Influence

Many decisions have been taken already. But many more decisions are still to be taken, particularly about individual standards.
YOU can mould their shape by taking an **active role** in European standards work.

SOME ACTIONS TO CONSIDER

- ☐ Identify any changes that would open major opportunities for, or pose major threats to, your business.
- ☐ A spread of opinion obviously carries more weight than a lone voice. So work with others in your industry or through a trade association; involve users and producers; and try to carry your counterparts elsewhere in the Community with you.
- ☐ Build up a reasoned case: back it up with the best evidence you can assemble.
- ☐ If your concern is about a **Directive**, then tell your usual DTI contact point or your local DTI office - and the earlier you do so the better.
- ☐ If your concern is about a **standard**, then tell BSI (contact points given on pages 7-9).
- ☐ Better still, argue your case, through your trade association, in the BSI Technical Committee and help represent BSI in its European standards work. **The more you contribute, the more likely you are to succeed.**

Implement

European standards could affect every aspect of your business. Plan to exploit the opportunities. Identify the changes you need to make, and then implement those changes. Remember, there will be more decisions taken – so keep up-to-date. Reading DTI's newsletter "Single Market News" will be a good start. Another way is by using the "Spearhead" database on the content and progress of Community legislation – more details on page 10.

AREAS TO EXAMINE

Purchasing

- [ ] How can you use European standards to get better value in what you buy?

Product development

- [ ] How can you take advantage of European standards, and likely European standards, in your product development?

Production

- [ ] How can you take advantage of European standards in your production processes?

Marketing

- [ ] How can you use European standards to improve your service to your existing customers and to win new customers?

THYSSEN

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Betreff

Dear Mr. Roman,

as promised at the latest Galfan Meeting I'll give you some information on standardization of Galfan.

1. EN (European Norm/Standard).

Cocor has advised ECISS/TC 27 (European Commission for Iron and Steel Standardization/Technical Com. No. 27) to prepare a draft for an EN for 45 Zn/ 55 Al; 30 Zn/70 Al; 95 Zn/5 Al. The next meeting will be October 30/31.90 and we will put this on the agenda. (I am the chairman of TC 27.)

2. ISO

On the 19th meeting of ISO/TC 17/SC 12 on September 26./29.89 at Borlänge it was unanimously agreed that the secretariat would petition the TC 117 Central Secretariat for work covering Continuous hot dip zinc - 5 % aluminium - misch metal coated steel sheet.

Best regards
Thyssen Stahl AG
Forschung
- Oberflächenveredeltes Feinblech
und Werkstoffprüfung -

(Klotzki)

P.S. Please, forward a copy to Dr. Lynch. Thanks.