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MINUTES OF THE
EIGHTH GALFAN LICENSEES MEETING

Tokyo, Japan

April 21, 1986

INDUSTRIAL CONFIDENTIAL

INTERNATIONAL LEAD ZINC RESEARCH ORGANIZATION, INC.

MINUTES OF THE EIGHTH GALFAN SHEET LICENSEES MEETING

Held At

Japan Mining Industry Association Conference Room
Tokyo, Japan

On

April 21, 1986

ATTENDANCE

NAME	ATTENDANCE
R. Barrett	ZALAS
B. Bramaud	Ziegler
E. Buscarlet	Ziegler
B. Cathcart	Palmer Tube Mills Australia
N. Clark	New Zealand Steel Ltd.
J.F. Cole	ILZRO
T. Deguchi	Nisshin Steel Co.
F.E. Goodwin	ILZRO
J. Hamilton	New Zealand Steel Ltd.
T. Hiramoto	Yodogawa Steel Works
Y. Hirose	Nisshin Steel Co., Ltd.
Y. Hoboh	Sumitomo Metal Industries, Ltd.
H. Hodds	Stelco
H. Hosoda	Kawasaki Steel
K. Ichiyama	Mitsui Mining & Smelting Co., Ltd.
K. Ishiguro	Kawatetsu Galvanizing Co., Ltd.
N. Kimiwada	Sumitomo Metal Industries, Ltd.
T. Kiyasu	Kawasaki Steel
T. Kuniyasu	Kawasaki Steel
H. Kusubashi	Sumitomo Metal Mining Co., Ltd.
J. Lorenz	Thyssen AG
T. Matthews	Australian Associated Smelters
J. McAuliffe	ZALAS
R. Mieloo	Stelco
M. Minami	Mitsubishi Metal Corporation
T. Mori	Kawatetsu Galvanizing Co., Ltd.
H. Nagasaki	Sumitomo Metal Industries, Ltd.
I. Nakase	Sumitomo Metal Industries, Ltd.
S. Niltawach	Chulalongkorn University, Thailand
M. Nishioka	Nisshin Steel Co., Ltd.
K. Okano	Kawatetsu Galvanizing Co., Ltd.
K. Nonaka	Yodogawa Steel Works, Ltd.
S.F. Radtke	Rasmet Cosmos Engineering, Inc.
G. Reh	Hoesch Stahl AG
K. Sakamoto	Nippon Mining
Y. Sawatani	Nisshin Steel Co., Ltd.

NAME	COMPANY
S. Shijima	Kawatetsu Galvanizing
Y. Shimada	Sumitomo Metal Industries, Ltd.
P. Sippola	Rasmet
R. Sjostrom	Rasmet
A. Skenazi	CRM
S. Sugimoto	Mitsui Mining & Smelting Co., Ltd.
H. Tanihara	Kawatetsu Galvanizing Co., Ltd.
H. Tokunaga	Japan Lead Zinc Development Association
S. Yamamoto	Mitsui Mining & Smelting
A. Yasuda	Kawasaki Steel Corporation
A. Yazaki	Kawasaki Steel

MEETING CONVENED

The meeting was convened by Dr. Frank Goodwin at 9:00 a.m. He welcomed the licensees to the meeting and noted that this was the first licensees meeting which really was for sheet discussion only. The wire licensees now have a separate meeting of which the first was on February 21st. He announced that there are now three new licensees since the last meeting: Indiana Steel & Wire of the U.S., Peine Saltzgitter of West Germany and Cantieri Metallurgies Italiani of Italy. He also noted that this was a very special week for GALFAN because three production runs are being run. Hoesch in Germany, Weirton Steel, and Gregory Galvanizing, U.S.A., are all producing this week. He then introduced Dr. J.F. Cole, President of ILZRO, to the group. Dr. Cole also welcomed the attendees to the meeting and noted that this was the first GALFAN licensees meeting to be held outside of Europe. He thought this was appropriate since Japan is where GALFAN was first shown to be commercially viable. This was primarily done to the efforts of Yodogawa Steel Company. He gave his special thanks to the Japanese ILZRO members who have helped ILZRO with their organization and financial support. He also gave special thanks to the steel companies, Kawasaki and Yodogawa for allowing the licensees to visit their plants. He also acknowledge the presence of Dr. Radtke who was instrumental in the GALFAN development and introduced it to Japan. Dr. Cole then introduced Mr. Yamamoto, who represented the Japanese members of ILZRO, and who is a member of ILZRO's Board of Directors. Mr. Yamamoto thanked all the participants for coming to this meeting, particularly those who had come from overseas. He noted that he was very pleased to have the plant visits arranged and expressed his appreciation to those who helped the group today with the arrangements. The attendees were then all asked to introduce themselves to the group and an attendance roster was circulated.

C.R.M. RESEARCH REVIEW

Mr. Skenazi noted we were nearing the fifth anniversary of the first commercial trial of GALFAN at Ziegler. Thus, a lot of good corrosion information should become available in the near future. His presentation had two parts consisting of the effect of coating composition of performance and a corrosion data report. The range of compositions studied is given in the attached paper. The ASTM specification has several impurities listed including silicon, lead, copper, nickel, titanium and zirconium. A slide of the simulation apparatus used for this work was shown. His results show that the aluminum composition of the overall coating changes with bath temperature due to the formation of an intermetallic layer. The coating weight also changes with the layer thickness. He found that silicon suppresses the intermetallic at high temperatures unlike the silicon free alloy, which has a significant intermetallic layer. Conclusions are given in the text. He also found that antimony levels of 200 ppm gave no evidence of intergranular corrosion.

Mr. Hoboh asked why such a high bath temperature was needed. Mr. Skenazi noted that a high bath temperature is really not needed for GALFAN. However, several licensees run at the higher temperature because they are familiar with it from conventional practice and hence that needs to be characterized. Mr. Hodds asked if the higher bath temperature was needed to overcome bare spots. Mr. Skenazi noted that this was not necessary and that a sufficient mischmetal addition would overcome bare spots. He noted that bath temperatures are normaly in the range of 430-460 degrees C. Mr. Hodds asked if Superzinc was more susceptible to intergranular corrosion than GALFAN. Mr. Skenazi noted that he saw no difference between the two coatings regarding intergranular corrosion. For the zinc 5%-aluminum alloy in general, magnesium or the mischmetal additions will suppress intergranular corrosion at low levels, around 50 ppm or so, but as the lead level is increased to 100 ppm, both are ineffective in preventing intergranular corrosion. Mr. Clark asked if adherence was affected at high temperatures. Mr. Skenazi noted that at high pot temperatures, problems are seen with adherence due to growth of the intermetallic layer. Dr. Radkte noted the old work which had been done with impurities when die casting alloys, which showed that antimony affected the impact strength of the die casting alloys. Thus, the level of antimony which is allowable is probably not much higher than that discussed today.

Mr. Skenazi then presented the atmospheric corrosion work conducted recently which is now comprehensively done for one year of atmospheric exposure in several environments. These remarks are also attached to these minutes. He reviewed the previous corrosion data and noted that the new long-term program is set up to run for 15 years using samples of 200 x 150 millimeter size. The galvanized material comes from Phenix Works, the Galvalume from Arbed and the GALFAN from five different producers in Europe and Japan. Slides of the four different sites were shown and the effect of temper rolling, chromating, spangle, and gauge was shown for all atmospheres. He noted that the losses shown are the average of both sides together, expressed per side. However, only the top side showed significant weathering. Mr. Hodds asked what type of chromating was used and Mr. Skenazi replied that the classical ones were used in all cases. In the marine environment, the effect of the process variables was shown to be more important than in the other environments. This environment is particularly hostile because of the effect of salt and sulphur dioxide that is combined. The effect of edge corrosion is seen when comparing samples from the old and new exposure program. The old samples showed much more influence of edge effects. The next report like this will be two years from now and will be on the three year corrosion data. Mr. Hodds asked if any recent work had been done on painted product by CRM, and Mr. Skenazi noted that none would be reported here. The last time such data was reported was at the Surtech Meeting in Berlin. A copy of this paper is enclosed. Mr. Kimawada asked why the nitrogen was used in the simulation apparatus. Mr. Skenazi noted that this was the only was to conduct this work in the laboratory. They have not studied the use of nitrogen with wide strip production. Mr. Hirose asked if CRM has ever noticed local corrosion on samples, for instance white rust on the grain boundaries. He noted that he has results showing local white rusting on grain boundaries after long-term exposure, in both severe, industrial and severe marine environment. These may lead to a bad effect on the substrate for prepaint.

TECHNICAL REPORTS FROM LICENSEES

Yodogawa

Mr. Hiramoto presented the Yodogawa technical report. His remarks are attached to these minutes.

Mr. Hodds asked what strip temperature and pot temperature were best for reducing the craters. Mr. Hiramoto replied that the range of 460-560 degrees C was best for strip temperature and 400-500 degrees C was best for the bath temperature. Mr. Hodds asked if any intermetallic formation was seen with the higher bath temperature. Mr. Hiramoto replied that the intermetallic layer was not seen. Mr. Skenazi noted that this is probably due to the shorter immersion time at Yodogawa compared to laboratory results. Dr. Goodwin asked if ash formation is more of a problem at a higher bath and strip temperatures. Mr. Hiramoto replied that ash seen inside the snout then it must be removed. Dr. Goodwin asked how often it was removed, and Mr. Hiramoto replied that it was removed once a day. Mr. Clark asked what the dewpoint and gas composition was in their reducing section. Mr. Hiramoto replied that the dew point was -40 degrees C and that the gas composition was 25 percent hydrogen at first, which was later reduced to 11 percent. Mr. Barrett asked at what point the reducing gas was injected into the snout and what the flow raucing gas into the snout 30 centimeters over the bath surface. Mr. Barrett noted that the ash problem was due to the injection point being too close to the surface of the bath and that they should inject it much higher in the snout. Mr. Hiramoto asked why that was so and Mr. Barrett replied that it was due to the effect of the temperature of the reducing gas when it entered the snout. It tends to cool the vapor and create the ash which is seen. Along with this, the gas has a signout. It tends to cool the vapor and create the ash which is seen. Along with this, the gas has a significant oxygen potential even at -40 degrees C. Mr. Hirose believed that even at a higher introduction point, the ash formation would still be bad.

Mr. Barrett noted that if the atmosphere directly over the bath inside the snout could be kept more stable, than reaction would actually lower the dew point and condensing of the zinc vapor to ash would not occur. The idea is to not replace all the gas all the time directly over the zinc surface. Mr. Hodds asked what the wiping conditions were at Yodogawa. Mr. Hiramoto replied that they used air wiping.

ZIEGLER

Mr. Buscarlet presented Ziegler's recent work in a Zinquench trial. His remarks are attached to these minutes.

Mr. Mieloo asked what the bath size at Ziegler was. Mr. Buscarlet noted that it was 100 tons. He also noted that the production capacity was 15-30 tons per hour and that no difficulty was found in making coated steel using the Zinquench process which met the standards required. Good surface appearance was also seen. The bath analysis showed that the rare earth concentrations in the bath for Zinquench were much higher than those previously found for GALFAN. Lanthanum concentration ranged from .07 to .1 percent and the cerium concentration ranged from .07 to .1 percent also. This compared with previous rare earth analysis from normal GALFAN run which showed that compositions of 0.02 to .05 were found. He noted that their second trial would be in a few weeks during which they would coat dual phase steels.

Dr. Cole asked how the deep drawing quality of Zinquench coated steel was compared to GALFAN coated steel. Mr. Buscarlet noted that they both had equivalent drawability. Mr. Nagasaki asked if the coatings were batch annealed. Mr. Buscarlet replied that affirmatively noting that there is no overaging in this furnace. Mr. Barrett noted that one could expect further improvements in the properties with a continuous overaging. Mr. Buscarlet agreed with this and also noted that economies would be realized. Mr. Bramaud noted that he saw a big difference in the mechanical properties in Zinquench quench versus conventionally annealed steels. Mr. Hirose asked if there any alloy layer seen in the Zinquench structure. Mr. Bramaud noted that this depended upon the thickness. With a 0.7 millimeter thick steel, no layers were seen. However, with steels of 2 millimeter thickness, light alloy layer was seen. However, there was no problem with adhesion.

KAWASAKI

Mr. Okano presented Kawasaki's technical paper, which is attached to these minutes. He described the continuous coil coating line which uses a zinc phosphate pretreatment. The number one coater applies a primer, which is baked before proceeding to the number two coater which applies to the top coat. Inspection occurs after printing on the Resino GALFAN mark before final coiling. The influence of dissolved phosphate weight was shown which had been described in previous presentations by Kawasaki at the Licensees Meetings.

The paint discoloration tests were also shown, which were produced by accelerated tests using a dew cycle weatherometer. The effect of salt spray tests on painted material were shown. Six-thousand (6,000)-hour salt spray tests showed that much better results were found with GALFAN versus normal galvanized at the same coating thickness. A one-thousand (1,000)-hour cycle test also showed much better results for GALFAN compared to galvanized. Eighteen (18)-month exposure tests outdoors showed no deterioration on the cross and the edge with painted GALFAN. The locations of material were severe, marine they and industrial areas. Almost all of Kawasaki's product is used for roofing and they give a 10-year warranty on this product against red rust.

Mr. Hodds asked if any panels exposed had tension bends. Mr. Okano replied that they did not yet have results from these panels, that the work was still in progress. Mr. Buscarlet asked in the surface treatment if the degreasing and phosphate treatment was the same as used for normal galvanized. Mr. Okano replied that it was different than that at which they used for galvanized. Mr. Buscarlet thinks they may have to decrease the concentration of the degreaser. Mr. Okano replied that he would discuss this detailed process more during the plant tour on the next day. Mr. Hamilton asked for details of the 10-year warranty. Mr. Okano noted that it differed for different areas of exposure. Mr. Hodds asked if the GALFAN used for painting was skin passed. Mr. Okano replied yes and that this is the normal procedure for coated material in his company.

SUMITOMO

Mr. Hoboh presented recent work at Sumitomo. The coil coating procedures were described as given in the attached sheet along with the test materials used which are also shown. Primarily, roofing materials used in Japan have a minimum coating of 250 grams/m^2. Panels were prepared for testing in their work by putting them through a 90 degree bend after coil coating. Coil coated material was also roll formed to two different profiles as shown in the enclosure. A cyclic corrosion test was used as shown in the attachment. He believes this is the best model for roofing.

Mr. Hoboh showed slides of the painted panels of GALFAN and galvanized after exposure. The 90 degree bend and roll formed panels gave much improved performance with GALFAN versus normal galvanized. The corrosion performance on the bends was excellent. The cut edge performance is the same as GALFAN with normal galvanized. Thus, his conclusions were that roll formed painted GALFAN offers superior performance to galvanized. This was remained motivation in obtaining the GALFAN license. However, the cut edge performance is no better.

Mr. Bramaud asked what the bend radius was in the profiles that were tested. Mr. Hoboh replied that they had a 2 millimeter radius. Mr. Clark asked what the gauge was and Mr. Hoboh replied that it .6 millimeters. Mr. Bramaud noted that Ziegler does not the same pretreatment for painting on their steel. They use a Bonderite 1303 which puts a light oxide on the panel before painting. They see edge blistering with their testing. He asked if the Mr. Hoboh thought the phosphate treatment can eliminate this. He noted that with the Bonderite 1303, they had the same problems as seen with the Bonderite 1300 which is a phosphate treatment. Mr. Hoboh replied that Sumitomo has not compared the Bonderite 1303 treatment with the phosphate treatment.

NEW ZEALAND STEEL

Mr. Clark's remarks on 4-year exposure data, soldering and marketing activities are attached to these minutes. He noted that New Zealand Steel has had material up for 4 years in a geothermal and severe marine environment. Their corrosion results are for the upper surface of the panel only. They noted that they are getting two times the corrosion life with GALFAN compared to galvanized in both atmospheres. It looks like the GALFAN panels will last six years in these environments versus three years for the galvanized. He noted that the severe marine environment in New Zealand was apparently not quite as bad as that in Belgium.

Painted panels were also put on corrosion exposure and all have a 1.7 millimeter bend. No white rust products were seen on the bend whereas all galvanized panels have white rust corrosion products on the bends. The water borne system was seen to be the best paint system and he noted that it looks like new after four years. He is not sure of the pretreatment for the system but it is probably a chromate treatment.

New Zealand Steel has also evaluated soldering processes for GALFAN because a fair amount of soldering is done in his market. They are rather keen on developing a soldering technique. They have found a suitable solder and flux. The filler metal which works best is 70% tin, 30% zinc. A proprietary flux is used, made in New Zealand, which is ordinarily used for soldering alumina. He believes it is based on a sodium flouroborate. They will do salt spray in long term corrosion tests to determine the life of the solder joints.

New Zealand Steel's market activity is also described in the enclosed remarks. Half of the material put out is painted and half unpainted. He noted that white rust is seen on chromated coils which have been sitting outside for some time, and these behalf the same as galvanized. He also noted that roll forming of unpainted GALFAN has caused a few problems with forming roll pickup of the coating. Sharp radius bends tend to pick up GALFAN on the roll within 20 meters of starting the material. This results in indentations and scuffing of material which follows.

Mr. Mieloo asked if New Zealand Steel temper rolls in line. Mr. Clark replied yes they do but that all material of GALFAN has been purchased so far. Dr. Goodwin if asked they lubricate with their roll former. Mr. Clark replied that no lubrication is used at New Zealand Steel on roll forming. Mr. Hodds asked if roll pick up occurs with galvanized. Mr. Clark replied that not as much pick up occurs as does with GALFAN. Mr. Hirose asked if there was indeed no problem with patina at New Zealand Steel and if galvanizing patina was also seen. Mr. Clark reinterated that there was no problem seen with the customer as far as patina was concerned. Mr. Skenazi noted that in France zinc producers make the roll zinc product for roofing and that a treatment is desired which makes the patina. This is seen as very desirable and probably depends upon the market. Mr. Hirose noted that in Europe, terne coated sheet has traditionally been used which has patina and thus this may explain the desirability of patina in other products. Dr. Goodwin noted that a patination oil has been developed for lead products recently in Europe. Mr. Hirose asked if the patina was seen by the group as good or bad. Mr. Bramaud said this depends upon the customer.

Mr. Clark showed slides of the roofing tiles used in New Zealand which account for 15% of the market for coated steel. GALFAN tiles have very good ductility which goes well in this market. They are also working with an insulated building panel producer and expect to have material ready for testing in one months. A slide of a shearing shed for sheep was shown which had one GALFAN panel in the middle of the roof. This appears to be doing very well and is hardly noticeable in the unpainted form compared to the galvanized sheet. Mr. Clark noted that 50% of the roofs in New Zealand are metal and that they have put a number of roll formed GALFAN roofs into the market place. These are all doing well. Mr. Hodds noted that in North America they apply oils for passivation for any materials which will come in contact with food stuffs. He asked if Mr. Clark or any of the other attendees had seen any reaction with oils with GALFAN. Noone in the group had had this experience with GALFAN. Mr. Clark noted that his company makes about 25% Grade E material and that he would be pleased to discuss the manufacture of this product with others present.

STELCO

Mr. Hodds reviewed some of the recent activities at Stelco. Slides were shown of undervehicle test panels which had undergone Arizona proving ground tests as set out Ford Motor Company. Test panels put out consisted of bent panels with bulges using cold rolled, G60 and G90 galvanized and GF40 and GF60 and GF90 galvanized. The coating weight losses for these samples after 30 APG cycles was 4.5 mils, 1.4 mils, 1 mil, .5 mil, .6 mil and .6 mil respectively. He noted that the GALFAN in general gave a 40% better result than galvanized. He noted that the Ford Motor Company, when presented these results, noted that they are not really interested in better coating protection than that afforded by normal galvanized. However, they would like equivalent coating protection at a lower coating weight with GALFAN. Mr. Hodds also presented atmospheric exposure results from Halifax, Hamilton and Vancouver. These represent a severe marine, industrial and marine site respectively. Galvalume, GALFAN and galvanized panels were shown. He noted that in the industrial atmosphere, GALFAN was outperforming the other two coatings but that he will view this result as preliminary. The big problem, he noted, was seen when converting weight loss to thickness loss with the three coatings. With Galvalume there is a problem in interpreting the results because the methods of corrosion is not the same as compared to galvanized and GALFAN.

Mr. Hodds also showed a slide of warehouse roof that belonged to Baycoat, which is 20 x 360 meters, and located in Hamilton, Ontario. This roof has been divided into six sections being prepainted and bare (not chromated). GALFAN, Galvalume and galvanized substrates are used with fluorocarbon, polyester and silicon polyester paints. The roof was just put on six months ago so that the first evaluation will be during May. Mr. Hirose asked about the number of APG cycles conducted and Mr. Hodds noted that 30 cycles were shown in the work described. With 60 cycles all of the coating is distressed and no comparisons can be made. Mr. Hirose asked if Ford thought GALFAN was better than galvanized. Mr. Hodds replied that he saw a potential at Ford for unexposed parts but did not believe that there was any chance GALFAN would be used on exposed body panels in America.

HOESCH STAHL

Mr. Reh noted that from their work with GALFAN, they beleived the eutectic composition was closer to 5.3% rather than the 5% as previously believed. On their production experience this week, they will check this out. He also noted that 17,000 tons per year was their target rate for GALFAN. This is revised upward from their previous estimate. He commented on the roll pickup problems of Mr. Clark and noted that he believed a light lubricating oil which disappears after roll forming would help. This used in the production at Hoesch.

MARKETING REPORTS

Ziegler

Mr. Buscarlet noted that GALFAN was being aimed by Ziegler and markets which were interested in performance. These are divided into two areas: steel for severe drawing such as for automotive and steel for better corrosion life. The product is sold as an improved product to the customer, at a higher price. There are very few developments with roofing and cladding, as they need to obtain more experience before approaching the market. Mr. Bramaud reported that in the European quota system, GALFAN was now classified as "other galvanized".

YODOGAWA

Mr. Tanaka reported on the marketing efforts by Yodogawa for GALFAN. A copy of his remarks are attached to these minutes.

Dr. Goodwin asked how many tons of GALFAN had been produced by Yodogawa so far. Mr. Tanakas replied that 40,000 tons had been made. Mr. Hodds asked if Yodogawa charges a premium for GALFAN over painted galvanized. Mr. Tanaka replied that they do charge such a premium.

ZINC AND LEAD ASIAN SERVICES

Mr. McAuliffe noted that Zinc and Lead Asian Services (ZALAS) has become active in GALFAN in the last few months. A copy of his remarks is attached to these minutes. He also gave the group a copy of their new brochure "Twelve Good Reasons For Choosing GALFAN". He noted that ZALAS would be going to the Peoples Republic of China next week with ILZRO for possibilities with Wuhan Iron and Steel Works there.

NORTH AMERICAN DEVELOPMENT

Dr. Goodwin presented a report submitted by Dr. Lynch of Zinc Institute on recent market developments within North America. Slides were shown of a appliance wrappers for a North American washing machine manufacturer which will either be coil coated or powder painted after forming. Washing machine tops, motor brackets and bottoms are under consideration. Wrapper for exterior mounted roof air conditioners are another important new application. Underwriters Laboratories will immediately approve GALFAN with a GF65 coating as equivalent to normal galvanized G90. After further testing, if is possible that they will also prove GF60 as equivalent to G90. Another application with very good potential is that of GALFAN garage doors for residential and commercial buildings. Rainwear applications are also being examined including gutters, elbows and down spouts. Housing for electrical equipment are also being considered.

In the automotive field, the work of Arc Tube continues with good demand for the transmission cooling line tubing from that producer. Ford recently won Zinc Institute's Award of Excellence for this application. The tubing is also being considered for power steering applications and gas tank lines. Ford is also considering GALFAN for use as weather stripping which is encased in rubber for door sides. Dr. Lynch subjmitted that Ford has specified GALFAN for the 1989 Thunderbird gas tank shield to protect the plastic gas tanks which will be used in that car. Slides were shown of the cab cawl and doorpost innter applications for Mach truck and the deck innter from Ford. These are all severe forming applications. ARticles have been written for American Metal Market, Materials Engineering, Machine Design, Purchasing World, Metals Producing, ASTM Standardization News, Appliance Manufacturer, Appliance Magazine, and Metal Building Construction News which helped in increas the plastic gas tanks which will be used in that car. Slides were shown of the cab cawl and doorpost inner applications for Mack truck and the deck inner from Ford. These are all severe forming applications. Articles have been written for American Metal Market, Materials Engineering, Machine Design, Purchasing World, Metals Producing, ASTM Standardization News, Appliance Manufacturer, Appliance Magazine, and Metal Building Construction News which helped in increasing awareness in the market of GALFAN's capabilities. The GALFAN data file put out by the Zinc Institute was also reviewed with the group. This includes various articles including the paper submitted to the Metal Bulletin's Coated Coil Conference in October 1985, the Fence Industry Magazine article and the SAE paper on automotive applications for GALFAN. Thus, much literature is available for the user to consider when evaluating GALFAN for various uses.

Mr. Hoods stated that one problem seen with the introduction of GALFAN in North America is the sensitivity to the grey patina. He believed that this would be a problem with its introduction. He also noted that Stelco was running its three galvanizing lines at full capacity presently and, thus does not see any way which they can run GALFAN in the near future.

Mr. Cathcart noted that Palmer Tube is still trying to come up with a suitable process for GALFAN-coated tube. They have tried a variety of fluxes and none yet produce a satisfactory coating.

PRODUCTION PLANS OF THE LICENSEES

Dr. Goodwin then asked each of the licensees to inform the rest of the group about their production plans for 1986. These are as follows:

Hoesch	- 17,000 tons
Kawasaki	- 15,000 tons, all painted
Nisshin	- 5,000 tons
Sumitomo	- First trial in July-actual tonnage may be 500 tons per qtr.
New Zealand Steel	- Importing material from other licensees
Ziegler	- 6,000 tons in 1986
Thyssen	- No production in 1986
Yodogawa	- 15,000 tons in 1986
Stelco	- No production in 1986

Dr. Goodwin noted that claims had recently been allowed in Russia for a GALFAN trademark. This was considered very unusual. The patent registration number is not yet known. He also noted that Australian paten number 544,400 was granted on October 21, 1985. This covers both the composition and use of GALFAN for galvanizing.

OTHER BUSINESS

Dr. Goodwin noted that he had recently received a letter from Maubeuge. The licensee was unable to be present at this meeting but they asked for our consideration of the coating bend tests which is in the GALFAN ASTM specification for sheet. This noted that flaking of the coating within 1/4 inch of the end of the bend specimen shall not be cause for rejection. This is the same as that appears for normal galvanized sheet. Maubeuge felt that flaking of the coating within 1/4 inch of the edge of the bend specimen should be cause for rejection. The licensees were asked for their opinion on this. Representatives from New Zealand Steel and Stelco noted that they wanted to examine this further. They believed that it might be possible to tighten up the distance from the edge where flaking was allowed from 5 millimeters down to 2 millimeters, but that made it impossible to say that flaking is totally prohibited against the edge. Mr. Barrett noted that flaking on the bend edge is entirely due to the taper profile caused by slitting. Both galvanized and GALFAN would have the same taper and thus, both would be expected to have the same sensitivity. It was agreed that the group would reconsider this problem at the next Licensees Meeting after carrying out some bend testing to determine if such a proposal was feasible.

Dr. Goodwin proposed that the dates of the next Licensees Meeting be November 12th and 13th, and that the Wire Meeting be on the 14th as previously suggested to the wire licensees. There being no objection, he stated that ILZRO would send out invitations for the next meeting to be held on these dates.

Mr. Hodds asked if the use of the GALFAN with the flux line had been developed further and if anybody was ready to run a trial with the use of GALFAN and flux. None of the licensees stated that they were ready to do so. Mr. Skenazi noted that the wire flux process had been worked out completely and that three or four wire lines would be running commercially by the end of 1986 using the single-dip process. Tube trials are now underway and it appeared that flux could be used with strip. This is awaiting further study.

Mr. Hoboh noted that Superzinc contains magnesium and asked if magnesium can be added to GALFAN without any problems. Dr. Goodwin noted that ASTM ingot specification for GALFAN says can be present up to .1 percent. It is not known whether this conflicts with a patent or not but it would be checked. Dr. Hirose asked if the Japanese GALFAN patent was under consideration yet and Dr. Goodwin noted that it was still in process. Mr. Hodds asked if the production cost of GALFAN is higher than that of galvanized excluding the cost of alloy. Mr. Bramaud noted that it is indeed higher with GALFAN because of problems with scrap. Mr. Hamilton noted that the North American report has shown developments in many fields except building panel. He asked why this had not reached the same stage of development. Dr. Goodwin noted that many substrates are competing in the building panel market in North America including Galvalume, galvanized, GALFAN, superzinc and others. Thus, great consideration is being given systems and no major user has yet said it will use GALFAN for building panel.

Mr. Mieloo noted that there were many operating questions remaining operating questions remaining on GALFAN including the occurrence of bare spots, the amount of zinc pickup relative to aluminum pickup and others. He had recently seen a GALFAN trial where it was necessary to raise the stip temperature to 920 degrees before eliminating bare spots which then resulted in overheating of the pot. He was also not sure of what cleaning was required in a vertical furnace and asked other licensees to comment on these. In response to his question about the use of steam for coating control with knives, none of the licensees use this process. Mr. Hirose noted that selective corrosion of primary zinc in some of these low cooled samples heated examined was occurring with long-term tests. He noted the necessity of uniform microstructure to prevent this problem.

Mr. Hodds and Mr. Mieloo noted the necessity of discussing operating problems more during the licensees meeting. Mr. Skenazi suggested that they first take an inventory of different coating defects to various licensees and discuss these during the next meeting. Dr. Goodwin proposed a session on coating defects and line operation during the next meeting. He asked Mr. Hodds to be Chairman of this session and Mr. Hodds agreed to do so if a representative from a company who had actually run GALFAN would not do so. Mr. Hoboh proposed that all licensees bring typical samples from their production with defects to the next meeting for this discussion. There was no objection to this.

MEETING ADJOURNED

There being no further business, the meeting was adjourned at 2:37 p.m.

8th GALFAN LICENSEES MEETING.

TOKYO, April 21, 1986

C.R.M. Report

1) Galfan alloy specification.
2) Atmospheric corrosion data

by A.F. Skenazi, B. Renaux and A. Davin
(respectivelly research metallurgists and project leader at CRM).

INTRODUCTION.

In 1981 the first 500 tonnes of Galfan coated steel were produced on an industrial line in France. The number of Galfan licensees has grown from the eight steel compagnies of the original consortium to more than thirty galvanizers.

The research conducted at CRM under the sponsorship of ILZRO resulted in the development of the Galfan alloy, and in its characterisation. Furthermore, different aspects of the processing of Galfan in sheet galvanizing as well as wire galvanizing have been evaluated.

In this report we will give the results obtained concerning the influence of different alloying elements on the behaviour of the Galfan alloy. This evaluation was made in view of the recent publication of the ASTM B 750-85 specification. The data in this specification were based on the experience gained by the Galfan licensees and the comparison with zinc aluminium die casting alloys. The elements included in the study were :

aluminium
silicon
lead
magnesium
lanthanum - cerium
antimony.

Previous studies have reported the effect of copper, nickel, zirconium and titanium on the surface aspect and performance of Galfan coated sheet. It appeared that copper additions increase the fluidity of the Galfan alloy. Zirconium and titanium were used as grain refiner and gave rise to a minimum spangle coating while Ni addition did not modifie the behaviour of the Galfan alloy.

The second part of this report concerns the corrosion data obtained after one year outdoor exposure at the four different sites :

urban - industrial (Liège)
marine (Oostende)
severe marine (Oostende)
rural (Eupen).

The corrosion data allow to quantify the effect of different parameters like the chromating, the temper rolling and the coating structure. The comparison with galvanized and Galvalume has to be made with these findings in mind.

Galfan alloy specification.

The Galfan alloy was developed as an eutectic Zn-5% Al alloy with ternary additions of lanthanum and cerium. This choice assures the lowest melting point and the highest fluidity. The initial range for aluminium was set at 4.8 to 5.2%. At present the limits are 4.7 and 6.2%. This wide range was given not only to allow in plant variations but also to assure certain characteristics or performances.

Three aluminium levels, i.e. 4.7, 5.2 and 6.2% were chosen for an evaluation of coating structure and analysis as well as for corrosion testing.

The galvanizing conditions are given in table 1. The results of the coating analysis are given in tables 2, 3 and 4 for respectivelly 4.7% Al, 5.2% Al, and 6.2%. These data reveal that no significant differences occur for the three aluminium levels. The outdoor exposure in the urban- industrial atmosphere of Liège is in progress.

The effect of a silicon addition at the maximum allowed level of 0.015% is very marked on the coating composition, as well as on the coating structure. The presence of silicon inhibits strongly the growth of an intermetallic layer especially at the higher bath temperature of 490°C. The data in table 5, compared to those in table 3, illustrate this effect. It appears that the Fe and Al content in the coating is much higher for a classical Galfan bath compared to the silicon containing one. No detrimental effect on the ductility at this level has been observed. The outdoor exposure is in progress together with the three other qualities of Galfan.

Special precautions have to be taken to limit the contaminatio of the Galfan bath by lead. The presence of lead in fact causes an intergranular corrosion of the zinc aluminium alloy in general and the Galfan alloy in particular. In wire galvanizing simulation tests, the lead level in the Galfan bath was gradually increased. The Galfan coated wires were subjected to the steam test and then deformed. The evaluation in the same steam test of the alloys with increasing lead levels showed a critical level of 100 ppm Pb. For higher level of lead the susceptibility to intergranular corrosion is high and it can be observed large cracks after the test. The effect of lead could be attenuated by the addition of lanthanum/cerium and/or magnesium. The critical level of 100 ppm Pb was however maintained. The recommandation to limit the lead level below 50 ppm as in the ASTM specification and even below 20 ppm, which is feasible in most cases for sheet galvanizers, should be respected in view of these results to assure an excellent quality of the Galfan coating.

The study of the effect of antimony is in progress, but the first results show no detrimental effect on intergranular corrosion at levels up to 200 ppm.

From this survey it can be concluded that :

1) the variation of aluminium within the range given in the ASTM B 750 specification alters neither the galvanizing kinetics nor the coating ductility or adherence ;

2) the presence of silicon at a maximum level of 0.015% inhibits strongly the galvanizing reaction at high temperatures, without deteriorating the coating adherence at low galvanizjng temperatures, silicon has no effect at low galvanizing temperatures ;

3) the lead contamination in the Galfan bath has to be restricted at the lowest possible level. At levels over 100 ppm a severe intergranular corrosion is observed ;

4) the inhibiting effect of lanthanum/cerium and/or magnesium of the intergranular corrosion limit the effects of lead but does not increase the critical lead level.

Atmospheric corrosion study.

The objective of the outdoor exposure program, which was initiated in 1984, is to determine the corrosion resistance of Galfan (compared to other coatings) in various atmospheres.

The samples with the dimensions of 150 x 200mm were exposed in the following four sites for the indicated period :

a) Liège (urban-industrial) :	October 31, 1984 to October 21, 1985
b) Oostende I (severe marine) :	December 5, 1984 to February 12, 1986
c) Oostende II (marine) :	March 2, 1985 to March 22, 1986
d) Eupen (rural) :	April 29, 1985 to April 4, 1986

The thickness loss was determined by the Anderson-Reinhard method (pickling for 3 minutes in a 80 g/l CrO_3 solution at 80°C and dividing the weight loss by the density of the coating - i.e. Galfan 6.6, galvanized 7.1 and Galvalume 3.75).

The experimental results allow to determine the effect of chromating (Cr), temper rolling (SKP) and the eutectic coating structure (ph). The detrimental effect of a heavy gage steel was also established. The results are summarized in tables 6, 7, 8, 9 and 10.

In table 6 a rough comparison of the three coatings is given without taking into account the full factor analysis as given in table 7. From this factor analysis a maximum and a minimum thickness loss after one year of outdoor exposure of Galfan coated panels can be determined and compared to chromated galvanized and unchromated Galvalume (see table 8). The superior corrosion resistance of Galfan compared to galvanized is furthermore illustrated in table 9 which gives the relative corrosion resistance of the different coatings.

In table 10 a comparison with the previously published data is given. These values corresponded to a one year exposure of Galfan coated samples produced during the first industrial trial by Ziegler in 1981. The sample size was only 50 x 100mm.

The next evaluation is planned after three years of outdoor exposure and will therefore be reported in 1988.

C.R.M.
April 1986

A detailed report of both studies will be given in the next ILZRO Progress Report n° 15, to be issued in August 1986.

8th GALFAN MEETING

TOKYO, APRIL 21, 1986

C.R.M. REPORT

GALFAN ALLOY SPECIFICATION

ATMOSPHERIC CORROSION DATA

ELEMENT	ASTM RANGE	CRM STUDY
Aluminium	4.7-6.2	4.7-5.2-6.2
Lanthanum-Cerium	0.02-0.10	0.05
IMPURITIES		
Silicon	0.015 max	0 - 0.015
Lead	0.005 max	0 - 200 ppm
Magnesium	-	0.03
Antimony	-	0 - 200 ppm
PREVIOUS STUDIES		
Copper	-	0.5-1.0
Nickel	-	0.01
Zirconium	-	0.01
Titanium	-	0.01

TABLE 1 - GALVANIZING CONDITIONS

Surface preparation

Pickling in hydrochloric acid
Heat treatment under N_2-H_2 atmosphere.

Immersion conditions

Galfan alloy
Bath temperature 440°C - 490°C
Immersion time 5"
Exit cooling Nitrogen jet

TABLE 2 - COATING ANALYSIS FOR Zn-4.7% Al-MM BATH.

Bath Temperature	g/m²	% Al	% Fe
440°C	250	4.3	0.10
490°C	480	13.5	12.4

TABLE 3 - COATING ANALYSIS FOR Zn-5.2% Al-MM BATH

Bath Temperature	g/m²	% Al	% Fe
440°C	180	5.3	0.18
490°C	560	13.4	12.4

TABLE 4 - COATING ANALYSIS FOR Zn-6.2% Al-MM BATH

Bath Temperature	g/m²	% Al	% Fe
440°C	175	5.6	0.18
490°C	530	15.1	13.2

TABLE 5 - COATING ANALYSIS FOR Zn-5.2% Al-MM-Si BATH

Bath Temperature	g/m²	% Al	% Fe
440°C	240	4.5	0.08
490°C	250	5.9	2.0

CONCLUSIONS.

* For 4.7 < Al < 6.2
  No effect on
    Galvanizing kinetics
    Adherence

* For Si = 0.015%
    Strong effect on galvanizing kinetics at high temperature.

* Outdoor exposure in progress.

LEAD CONTAMINATION

PROCEDURE :

Wire galvanizing simulation
Steam testing of alloy and coated wire.

RECOMMANDATIONS :

	Pb Max.	Pb Prefered Max.
Ingot	50 ppm	20 ppm
Coating	100 ppm	50 ppm

REMARK :

Inhibiting effect of mischmetal and/or magnesium does not alter these values.

TABLE 6.

ATMOSPHERIC CORROSION DATA

Thickness loss (µm) for exposure site in

	LIEGE Urban		OOSTENDE I Severe marine		OOSTENDE II Marine		EUPEN Rural	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Galvanized	-	2.0	-	5.4	-	2.4	-	1.00
Galfan	1.2	1.0	3.8	3.5	2.3	2.2	0.90	0.65
Galvalume	0.6	-	2.6	-	1.1	-	0.35	-

(1) Unchromated (2) Chromated

TABLE 7

FACTOR ANALYSIS

	LIEGE	OOSTENDE I	OOSTENDE II	EUPEN
SKP(µm)	0.1	0.2	0.2	0.15
Cr(µm)	0.2	0.2	0.4	0.25
ph(µm)	0.4	0.6	0.8	0.35
edge(µm)	0.7	1.2	1.2	0.45
Min.A.C.(µm)	0.7	2.8	1.4	0.30

TABLE 8

COMPARATIVE DATA

Atmosphere	Thickness loss (μm) for coating: Galvanized	Galfan max	Galfan min	Galvalume
Urban	2.0	1.4	0.7	0.6
Severe marine	5.4	3.8	2.8	2.6
Marine	2.4	2.8	1.4	2.2
Rural	1.0	1.0	0.3	0.3

TABLE 9

RELATIVE CORROSION RESISTANCE COMPARED TO GALVANIZED

Atmosphere	Galfan	Galvalume
Urban	1.4 - 2.9 x	3.3 x
Severe marine	1.4 - 1.9 x	2.1 x
Marine	0.9 - 1.7 x	2.2 x
Rural	1.0 - 3.3 x	2.9 x

TABLE 10

COMPARISON WITH PREVIOUS RESULTS (1983-1986)

Thickness loss after one year exposure (μm)

	Urban (1) - (2)	Severe Marine (1) - (2)	Marine (1) - (2)	Rural (1) - (2)
Galvanized*	1.8 - 2.0	9.2 - 5.4	2.5 - 2.4	1.2 - 1.0
Galfan**	1.6 - 1.2	4.2 - 3.8	2.7 - 2.3	1.3 - 0.9
Galvalume**	1.6 - 0.6	7.2 - 2.6	2.3 - 1.1	1.4 - 0.3

* Chromated ** Unchromated

(1) 50x100mm samples (2) 150x200mm samples.

April 21, 1986

PRODUCTION RESULT OF YODO-GALFAN

KURE PLANT,

YODOGAWA STEEL WORKS, LTD.

1. INTRODUCTION

We introduced a license on Galfan on March 24, 1982 and we started the first trial on the conventional Continuous Galvanizing line on October 4, 1982. From the beginning, bare spots were not observed and adhesion of Galfan coating was excellent. However in the early stages the surface apppearance was not satisfactory due to minor groove defects and spot craters. Based on the experience and achievement during the trial productions, we have made changes in strip temperature, bath temperature and other conditions and as the result, we could remarkably reduce the groove defects and craters and now we present the result in this report.

2. MANUFACTURING PROCESS

2-1 Speciifications of Continuous Galvanizing Line (CGL)

Name of Line	No.2 CGL in Kure Plant
Type	Sendzimir (NOF)
Strip Thickness	0.15 - 1.0 mm
Strip Width	610 - 1,219 mm
Line Speed	150 m/min (Max.)
Production Capacity	10,000 t/mon.

2-2 Bath Exchange

Since Armco iron pot is used in No.2 CGL for conventional galvanizing, we performed the following method for production of Galfan.

1) Pumping out of conventional molten zinc

2) Exchange iron pot for cast iron pot which is used for Galfanizing

3) Changing with Galfan ingots

4) Melting of Galfan alloy

In addition, after the production of Galfan was completed, we took the same method to return to conventional galvanizing.
Therefore, approximately three days is needed for this change.

2-3 Material Used

We used aluminum killed low carbon steel (as rolled) as the base metal.
The thickness of the strip was 0.27 - 1.0 mm and its width was 711 - 1,219 mm.

2-4 Conditions for Production

The following table shows the conditions for the first and the latest production.

Item	First	Latest
Line Speed	50 - 120 m/min	55 - 130 m/min
Reduction heating Temperature (Furnace temperature)	810 - 860°c	890°c
H2 Content	25%	11%
Strip temperature into Bath	460 - 500°c	460 - 560 c
Bath Temperature	430 - 440°c	480 - 500°c
Spangle	Regular	Regular and semi-minimized

3. PRODUCTION RESULT

3-1 Galfan Bath Composition

The following table shows the value analyzed for bath compositon at about 50cm depth.

Element	Composition (Wt %)
AL	4.7 - 5.1
Fe	0.01 - 0.02
Pb	0.001 - 0.003
La	0.005 - 0.04
Ce	0.01 - 0.08

3-2 Galfan Coating Properties

As for the bare spot and adhesion of coating to the base metal, we could obtain excellent results from the first trial but in the beginning, minor groove defects and spot craters were observed.
Therefore we tried the following procedures :

1) Increasing strip temperature into bath

2) Increasing bath temperature

3) Removal of ash in snout

As the result, groove defects and spot craters were remarkably reduced.

3-3 Painting Properties

As for the surface appearance and adhesion of paint film, it was almost equal to the conventional galvanized sheet but in the Salt Spray Test, blisters were observed at the cutting edge when paint for the conventional galvanizing sheet was used (so-called edge creep). This was solved by increasing the concentration of anti-rust pigment in the primer.

4. CONCLUSION

We had a few trials and could establish technology of producing commercially trouble-free Galfan steel sheet. However, we are still seeking a method to reduce downtime necessary for the pot exchange and we appreciate if you would give us some advice.

ZIEGLER S.A. 14th April 1986

S.R.D. BB/LP

ZINQUENCH

In this report, we will describe a new process bound to galfanized steel.

There is a growing demand for steels with the following properties :

- excellent corrosion resistance
- good drawing characteristics
- high strength

On the other hand, the production cost of these steels is a great factor that determines the choice of our customers.

The zinquench process answers this threefold target :

- anticorrosion
- steel metallurgical characteristics
- low making cost

It has been developed in the laboratory at the Helsinki University of Technology on behalf of the Finland Rasmet Company, owner of the patent.

1°) Definition of the thermal cycle :

It consists of a continuous annealing process (chart 1). The as cold-rolled sheet is annealed at a temperature of 800 to 850°C with a soaking of about 30 s. Then, it is slowly cooled up to 650/700 °C/s before being dipped in a galfan bath at 410°C. The cooling rate obtained is between 400 and 800°C/s, according to the thickness of the base metal.

As a reference, the chart 2 shows the cooling rates of the sheets obtained by the current processes on the coated lines :

- Jet cooling
- Roll quench
- Water quench

After this fast cooling, the sheet is out of the galfan bath and then overaged on line or out line.

The last phase of the process is temper roll.

../..

2°) Process advantages :

a) Deep drawing steel :

The very fast cooling rate from 700°C to the galfan bath temperature of 410°C allows a high supersaturation of solute carbon in the ferrite.

This property is fundamental for the precipitation of carbides during the overaging.

For example, we will show you :

- the influence of the cooling rate on the quantity of carbon in ferrite before and after overaging (chart 3).

Then, we will obtain excellent deep drawing properties.

We can also notice that in case of overaging on line, the processing time is shortened.

b) High strength steels :

When we use low alloyed steels (Mn) of about 1,2 %, a such cooling rate allows the easy transformation of austenite in bainite and martensite and then we obtain a good dual phase structure.

Industrial trial

We have runned an industrial trial for two days in our MOuzon plant.

Dimensional program : Thickness : 0,25 - 2,5 mm

Max. width : 1540 mm

Max. Speed on line : 100 M/mn

A special equipment is required for the galfan pot. As a matter of fact, it is necessary to evacuate continuously the calories brought by the sheet dipped in the bath at 700°C in order to maintain the galfan bath at 410°/420°C.

In the bath, the cooling is assured by tubes in which circulates the air under pressure. Propellers maintain galfan in circulation (chart 4).

The chart 5 shows the complete cooling system.

The air pressure is regulated by a special blower in a range from 1 to 15 bars. The efficiency of the cooling depends on this pressure.

With regard to the air, it is cooled with an exchanger air-water.

We have noticed that a pressure of 7 bars is sufficient to run a steel production of 30 T/hour.

Otherwise, we have checked the excellent homogeneity of the temperatures with thermocouples dipped in different bath points.

Mechanical characteristics obtained :

For this first industrial trial, we have mainly worked with regular aluminum killed steels.

The thermal cycle carried out is showned on the chart 6.

- The results obtained are excellent as you can see on chart 7.

Coating Quality :

a) Coating thickness :

We wanted to obtain coating thickness of 225 g/M2 and 275 g/M2 depending on the produced coils ; we had no difficulty to get these standards.

b) Coating aspect :

The high dipping temperature of the strip in the bath has improved the galfan aspect.

Conclusion :

The target of this trial was to show the feasibility of such a producing process and specially the control of the bath temperature.

This target has been reached.

We have also shown the interest of this process in order to obtain steels with very good deep drawing characteristics and at the same time an excellent coating adherence.

A second trial will be runned in a few weeks to confirm this process feasibility but also to study more specially the production of dual phase steels.

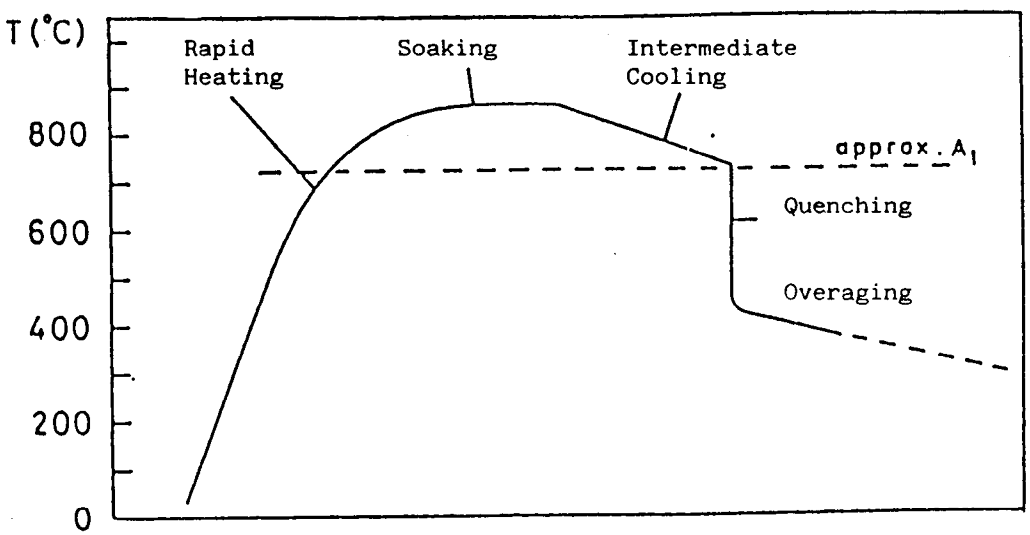

T(°C)
800
600
400
200
0
Rapid Heating
Soaking
Intermediate Cooling
approx. A_1
Quenching
Overaging

Chart 1

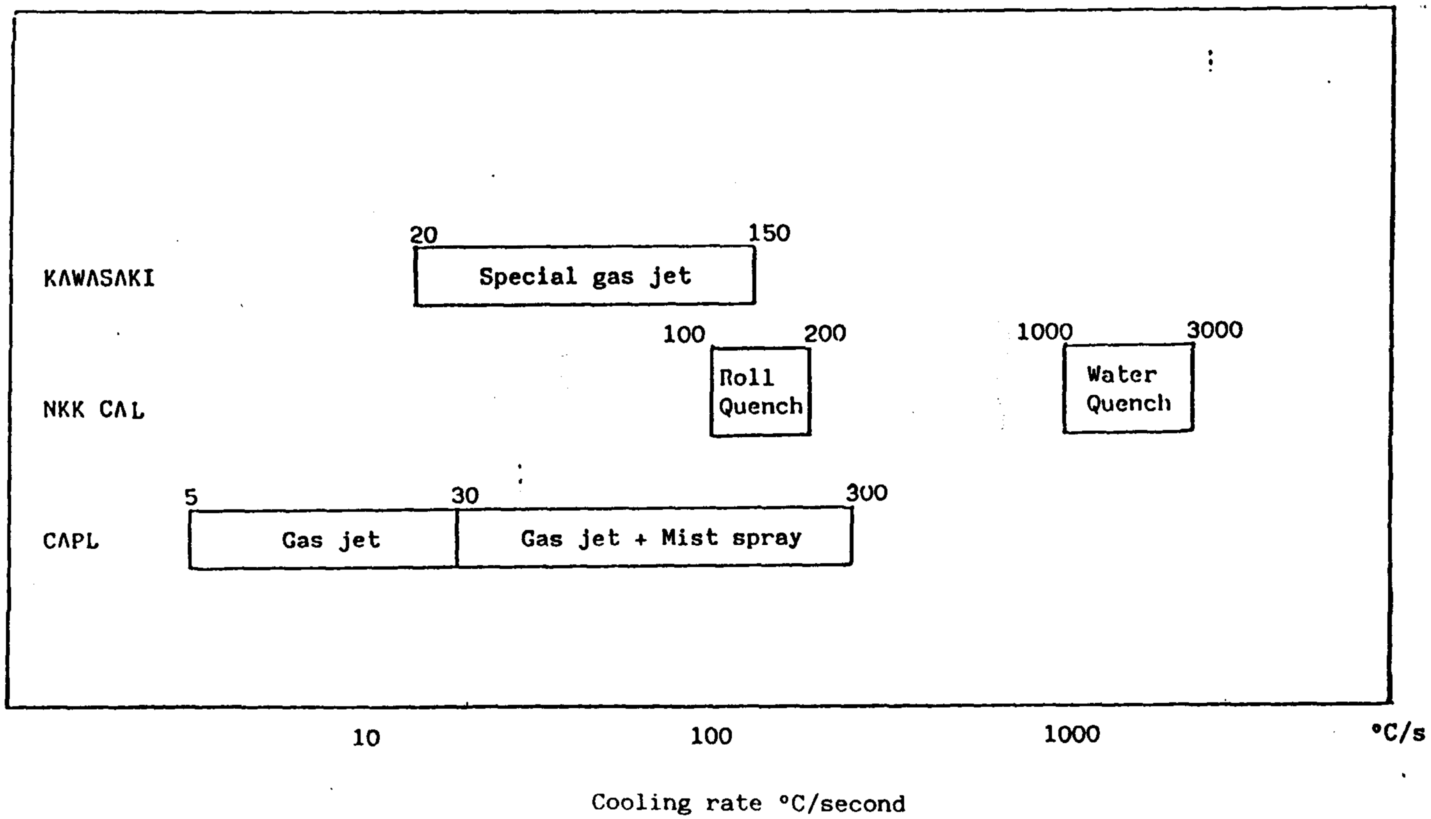

KAWASAKI
20
150
Special gas jet
NKK CAL
100
200
Roll Quench
1000
3000
Water Quench
CAPL
5
30
300
Gas jet
Gas jet + Mist spray
10
100
1000
°C/s
Cooling rate °C/second

Chart 2

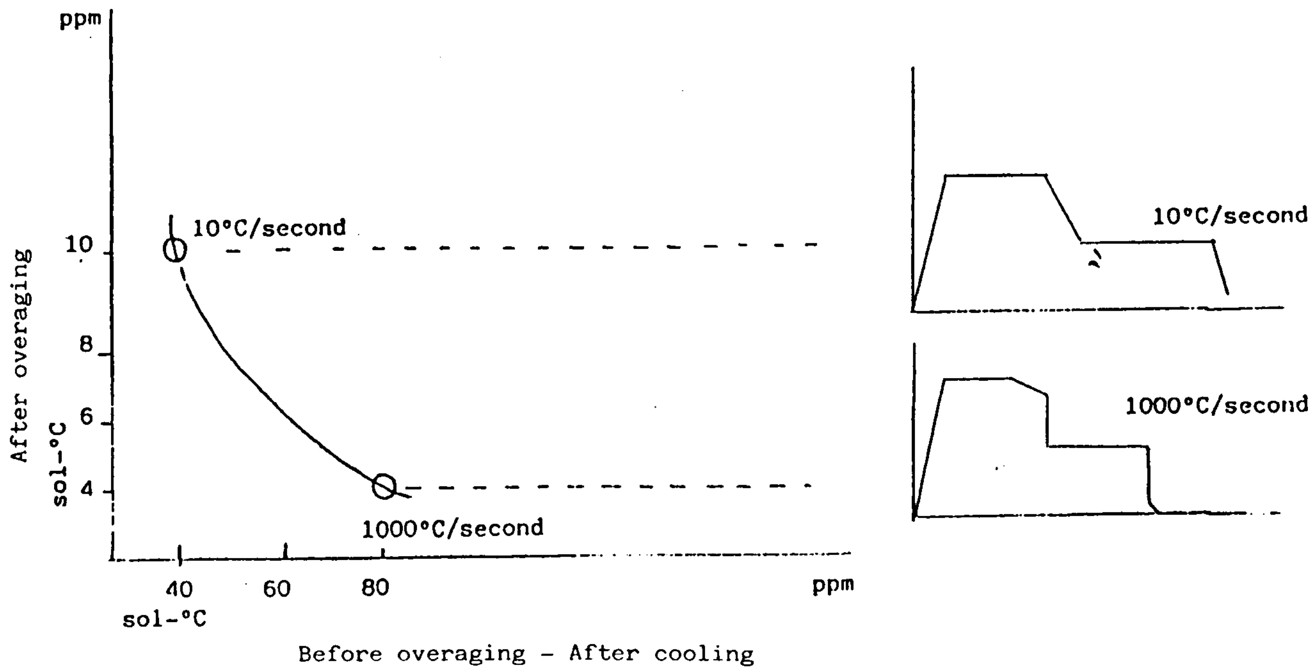

ppm
10°C/second
10
8
6
4
After overaging
sol-°C
1000°C/second
40
60
80
ppm
sol-°C
Before overaging - After cooling
10°C/second
1000°C/second

Chart 3

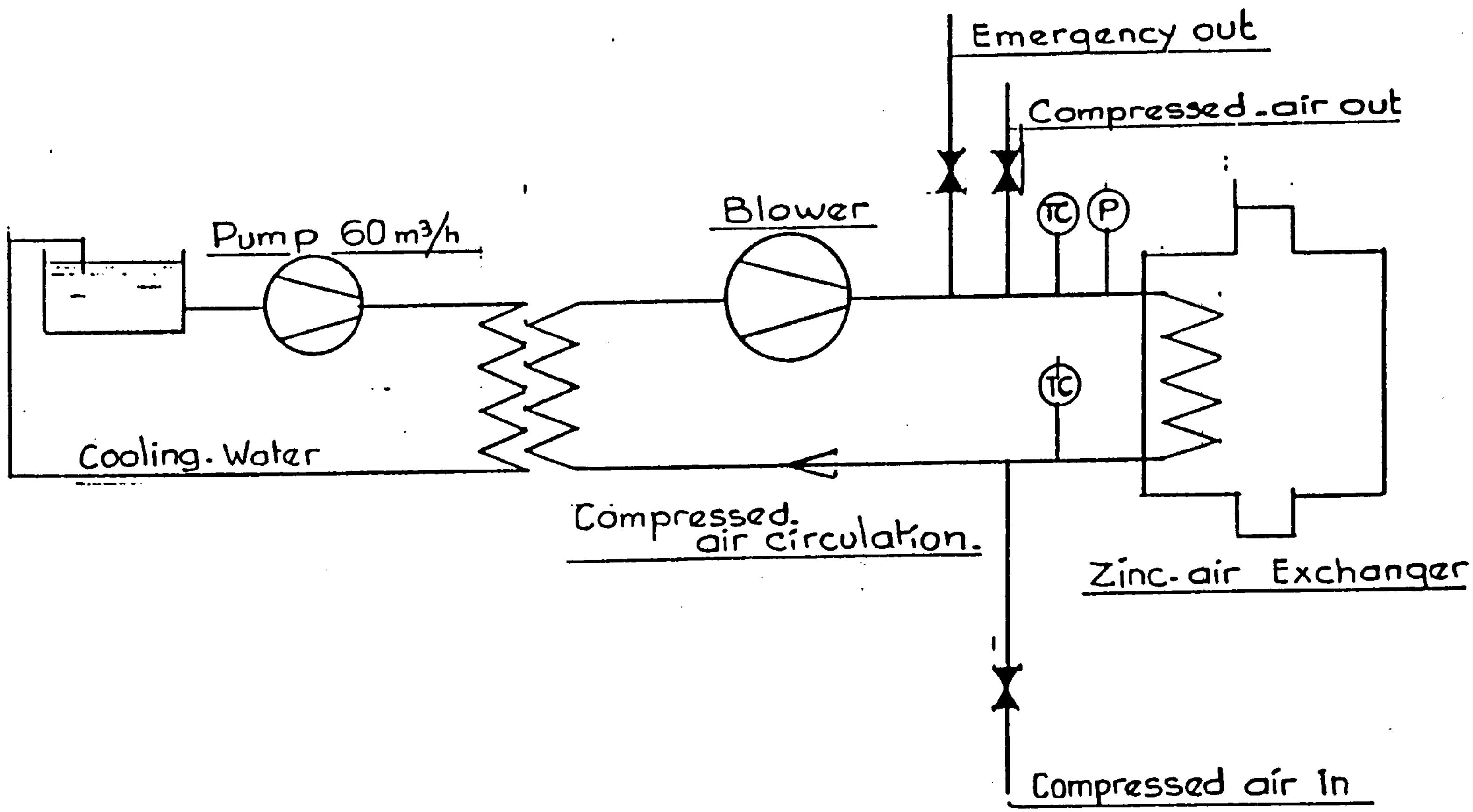
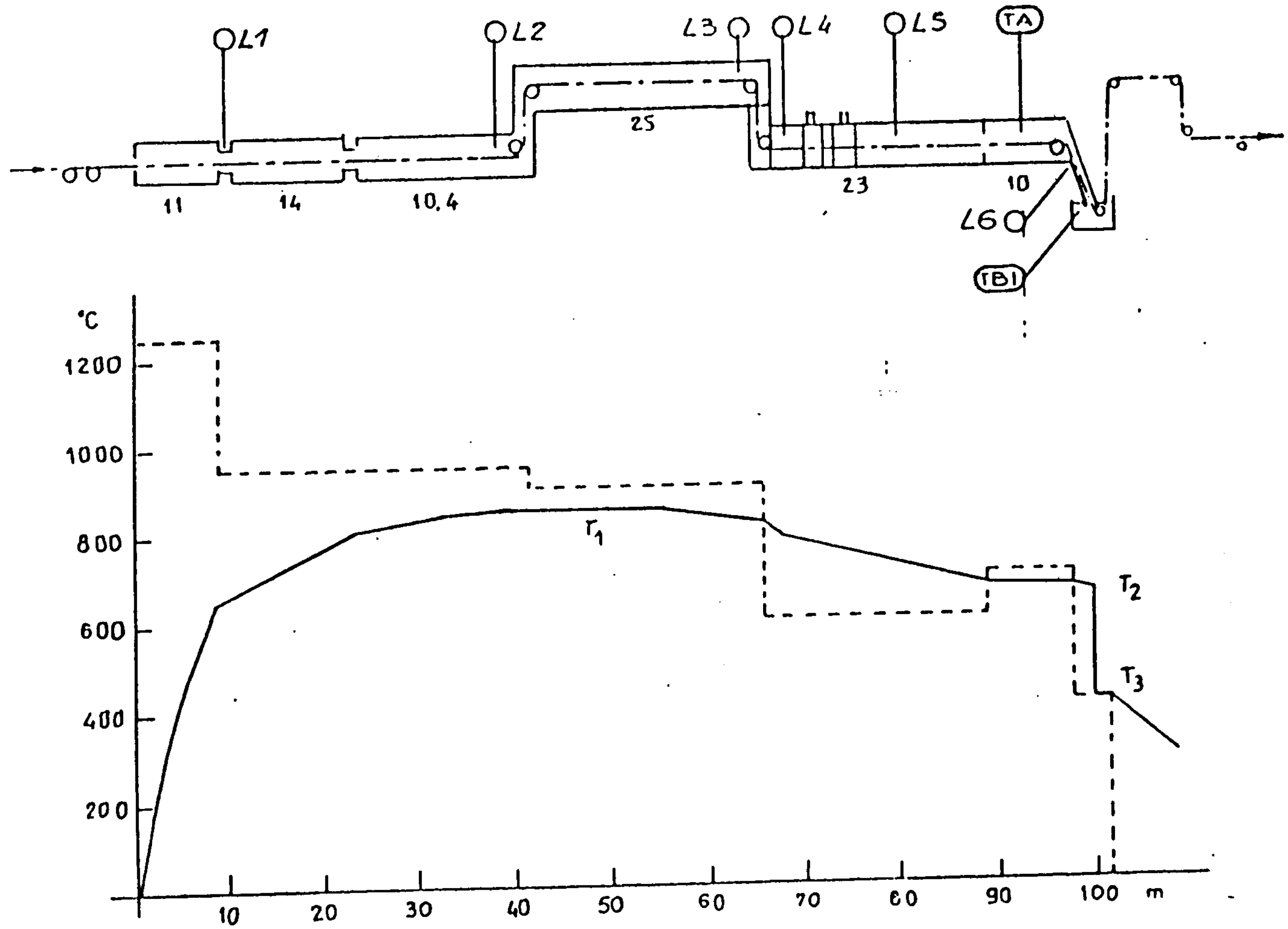


Chart 5

ZIEGLER. S.A. 08210 MOUZON

ZINQUENCH TECHNOLOGY
EXCHANGERS CIRCUIT

S.R.D. jp. H. 03.86



ZIEGLER. S.A. 08210 MOUZON

Chart 6

SCHEMATIC WIEV OF THE THERMAL CYCLE AND FURNACE TEMPERATURES.

S.R.D. JP.H. 03.86

ZIEGLER S.A. S.R.D.	ZINQUENCH	April 1986

Size 1250 x 0,70

Chemical Analyses :

C	Mn	S	P	Al	N	Coiling Temp.
0,020	0,17 0,25	0,015	0,08	0,045	0,0004	700°

Mechanical charecteristics after zinquench cycle + post annealing 280° (5 H) + temper roll 1 %

YS N/mm2	TS N/mm2	El %	$\bar{r}$	$\bar{n}$
150 to 180	290 to 310	39 to 42	1,7	0,22

Chart 7

THE ZINQUENCH PROCESS, FIRST INDUSTRIAL TRIAL AT ZIEGLER S.A., MOUZON, FRANCE, 1986.

S. Mäkimattila and P. Sippola, RAS-MET Ky, Helsinki, Finland
J.P. Hennechart, Ziegler S.A., Mouzon, France

1. INTRODUCTION

A new technique [x)] of hot-dip galvanizing has successfully undergone its first full-scale industrial trial. The trial, briefly summarized in this paper, was made in order to produce deep-drawable , Galfan-coated steels, and to test the functioning of the bath cooling equipment designed for the ZINQUENCH process.

2. PROJECT STATUS

The development of the ZINQUENCH process[2] began in 1981 with laboratory equipment at the Helsinki University of Technology. The experimental results were then verified on a continuous pilot line with a 90 mm strip width at Mefos Metal Working Research Plant in Luleå, Sweden, where production of high - strength dual-phase steels was successfully attempted.[3,4]

x) see ref.1, Promising New Zn-Al Alloy Quench Coating Process for Steel Undergoing Production Trials, "Industrial Heating", September 1985, S.F. Radtke.

3. THE ZINQUENCH TRIAL AT ZIEGLER S.A.

For the test period the Ziegler, Mouzon, hot dip galvanizing line No 2 was equipped with a specially designed, immersed cooling apparatus made by Ahlström Warkaus Engineering Works, Varkaus, Finland.

3.1. Description of the line.

The convertible triple-pot line (No 2) is able to process strip ranging from 0.3 to 3 mm in thickness and from 600 to 1500 mm in width. The maximum speed is 80 m/min. The furnace capacity is about 30 ton/h in full size width and a low annealing temperature. The line is schematically presented in Fig. 1. The principle of the bath cooling unit is shown in Fig. 2.

For the ZINQUENCH test the furnace section nearest to the Galfan pot was additionally insulated and heated in order to achieve a high quenching temperature up to 700 °C. The bath cooler consisting of two heat exchangers was designed to balance the bath temperature , even in respect to rapid stoppages of the line from full capacity of 30 ton/h. The maximum cooling effect of the heat exchanger, however, can still be more than doubled, if necessary.

3.2. Processing conditions

For all steel qualities the approximate annealing (soaking) temperature was adjusted to be about 850 °C.

The thermal cycle is schematically shown in Fig.3. The jet-cooling equipment, used in normal production, was set to give a lowest possible cooling effect. The zinc bath temperature was recorded by four point simultaneous measurement. The bath temperature stability was excellent in spite of large variations in the incoming heat (line speed). With manual control, temperature deviations , smaller than 1 - 2 °C, were easily obtained.

3.3. Coating weight and aspect

The coating weight was 120 - 275 g/m^2. The Ziegler Mouzon line No 2 has recirculating nitrogen gas knives. Most of the coils were coated with 225-275 g/m^2 coating.

The ZINQUENCH process permits large variations of the incoming strip temperature. According to Ziegler's experience, the strip surface quality was outstanding when operating with high immersion temperatures of 650-700 °C. In any case, the aspect was better than that of normal Galfan. No bare spots were observed.

3.4. Flatness of the galvanized strip.

The strips were slightly center-long. They showed no wavy edges which is a problem encountered with in other continuous-annealing and quenching processes. According to Ziegler's experience the deformations were acceptable.

4. GENERAL OBSERVATIONS

Transition from normal hot-dip galvanizing mode to ZINQUENCH mode was easy. The operation of the cooler was easy. The response time vs. variations in incoming heat is very short. If a line stoppage occurs, the primary heat exchanger is switched off to prevent undercooling of the melt. Automation of the bath cooling unit operations is very easy.

According to Ziegler S.A. the aspect of the ZINQUENCH - processed Galfan was better than that of normal Galfan. Due to the very high immersion temperatures , the wettability is good. The adherence of the ZINQUENCH-processed coating is good. Dross formation is the same as with normal Galfan production.

Formation of zinc fumes at the entry surface of the Galfan bath was even less than normal. This can be easily understood, if we think that the cooled melt is directed just to the entry section. Formation of metal vapor is strongly dependent on the melt temperature.

No corrosion of the immersed cooling equipment was observed after the trial. Indications of reactions between the equipment and the melt were found in propellers and pot-rolls. The corrosion rate will in any case be slow, due to the lower-than-normal bath temperature.

5. PRODUCTION COSTS

The production costs are the same as with normal Galfan or Zincgrip. At the Mouzon works the extra costs to operate the heat exchangers are balanced by the fact that no jet coolers are needed.
The waste heat may, in general, be utilized elsewhere.

6. PROPERTIES OF THE COATED STRIPS

6.1. Steels

The chemical compositions of the steels are presented in Table I . All steels were produced by Ziegler, except the steel SSAB , produced by Svenskt Stål AB (SSAB), Domnarvet, Sweden.

Typical mechanical properties obtained are presented in Figs. 4 - 7 as compared with the typical properties of steels processed by other methods, vacuum degassed for example.

The deep-drawing quality steel had exceptionally high $\bar{r}$ - valves and low yield-strength in the over-aged and skin-passed condition . The properties surpass, or equal, the properties of deep-drawable steels of other production practices.

Typical microstructure of the zinc-quenched and over-aged steel is shown in Fig.8. A large amount of precipitated carbides can be seen, especially after a suitable over-ageing treatment. A small part of the carbides precipitate on the grain boundaries, but by far the most cementite particles precipitate in the ferrite grain interiors. When suitably choosing the quenching temperature and steel chemistry, a desired intercarbide spacing can be produced to give optimum ductility of the final over-aged product.

6.2. Coating

The structure of the coating is largely the same as that of normal Galfan coating. The grain size of the coating, however, is somewhat smaller . This gives a more uniform , smoother surface. The ZINQUENCH process seems to exert a beneficial effect on the surface quality.

In some strips, due to the high quenching temperature, there is an intermetallic alloy layer that does not usually exist in normal Galfan production. In thicker sheets - over 1.5 mm - this alloy layer is continuous and has a good adherence to the base metal.

Formation of an intermetallic layer can be avoided if the circulation of the cooled melt is good enough. In respect to the use of rare-earth (mischmetal) additions, mixing of the bath is known to give a more homogenous distribution.

7. SIMULATION OF ON-LINE OVER-AGING

Because Ziegler´s hot dip galvanizing line has no facilities for direct over-aging , the coated coils were post-annealed elsewhere in a batch-type furnace. However, the on-line over-aging is efficient and economical after a rapid quenching process. Therefore, a laboratory simulation of on-line over-aging was performed with various samples from the ZINQUENCH process after the ZINQUENCH trial.

Due to the high supersaturation of solute carbon, a very rapid carbide precipitation takes place. The Aging Index (Fig. 9) was determined with tensile specimen at uniform deformation of 10 pct and after aging of 30 min at 100 ^{o}C. The Bake-Hardening Index (Fig. 10) was measured after tensile deformation of 2 pct and baking of 20 min at 170 ^{o}C.

It can be seen that a short over-aging treatment of 1-2 min at 350 ^{o}C is sufficient to provide a non-aging product after the ZINQUENCH process. The over-aging of the strip also leads to better formability and a lower yield strength of the product.

8. CONCLUSIONS

1. Concerning all aspects of the trial, i.e.
   - mechanical properties of the processed coils,
   - functioning of the bath cooling equipment,
   - quality and aspect of the eutectic (Galfan) coating.

the first industrial trial of the ZINQUENCH process has been successful.

2. Especially

- deep drawing quality steel with low yield strength and high r - valve are easily achieved with low - carbon, conti-cast steel.
- due to the high cooling rate during quenching , high supersaturation of solute carbon in ferrite follows. This enables rapid on-line over-aging and non-aging properties. The steels also have a considerable bake-hardening effect.
- high-strength dual-phase can be easily produced.
- bare spots have completely disappeared.
- adherence is as good as in normal Galfan production.

3. A second trial for production of dual-phase and other high-strength qualities is planned to take place in the very near future.

REFERENCES

1. S.F. Radtke, Promising New Zn-Al Alloy Quench Coating Process for Steel Undergoing Production Trials, Industrial Heating, September 1985.

2. P. Sippola. US - patent No 4,361,448, Nov. 30, 1982.

3. S. Mäkimattila, A hot-dip galvanized dual-phase steel, Intergalva ´85. Munich , FRG, E1 - E9.

4. S. Mäkimattila, E. Ristolainen, On the structure of a Zn - 5% Al hot-dip galvanized coating, Intergalva ´85, Munich , FRG, B1 - B6 .

TABLE I Chemical composition of the steels % 10^{-3}

DDQ-steels	C	Mn	Al	N	Si	HCT °C
SSAB	15	200-300	30-50	0.005	0.01	735
AS	30	200-340	35-70	0.004	0.005	720-750
CE	30-50	320-340	35-70	0.005	0.005	600
HS - Steel						
PR	140	1000				

TABLE II Mechanical properties

DDQ-steels as processed	YS (MPa)	TS (MPa)	EL (%)	r_m	n
SSAB	222	358	30	1.8	0.22
AS	226	343	33	1.7	0.212
CE	245	345	33	1.2	0.2
as over-aged, skin-passed					
SSAB	195	320	42	1.7	0.23
AS	195	320	39	1.7	0.23
CE	215	340	36	1.5	0.22
HS - Steel					
PR	335	535	23	1.0	0.2

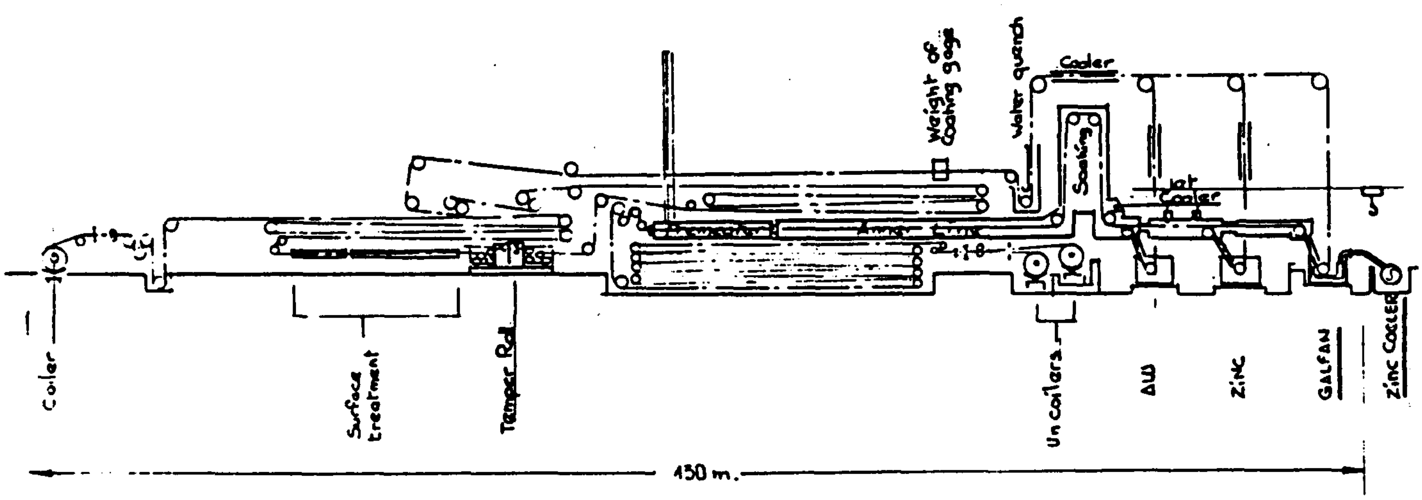


Fig. 1 The Ziegler , Mouzon, hot-dip galvanizing line n:o 2.

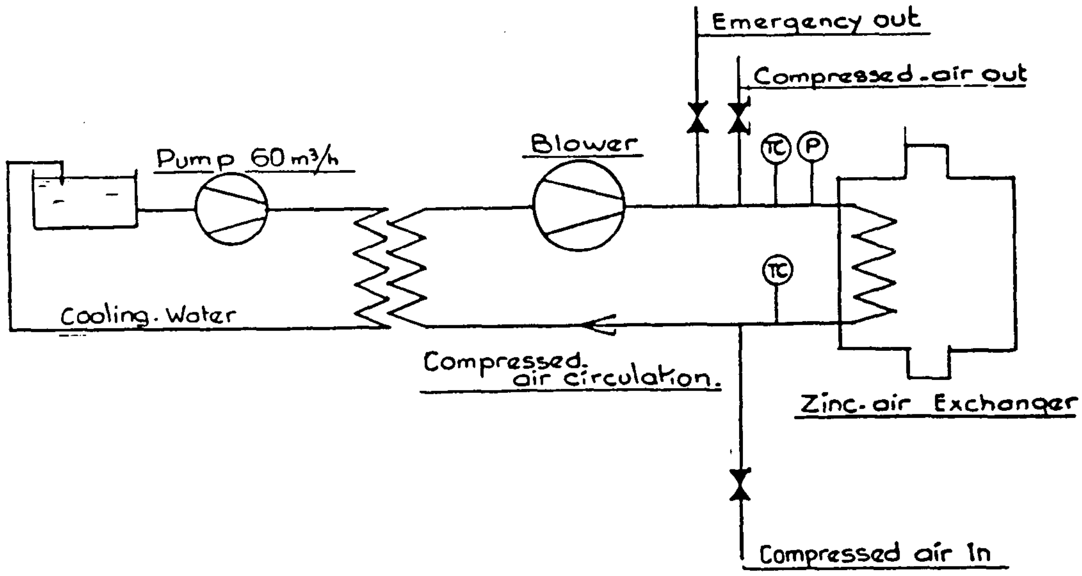


Fig. 2 Principle of the zinc bath cooling unit.

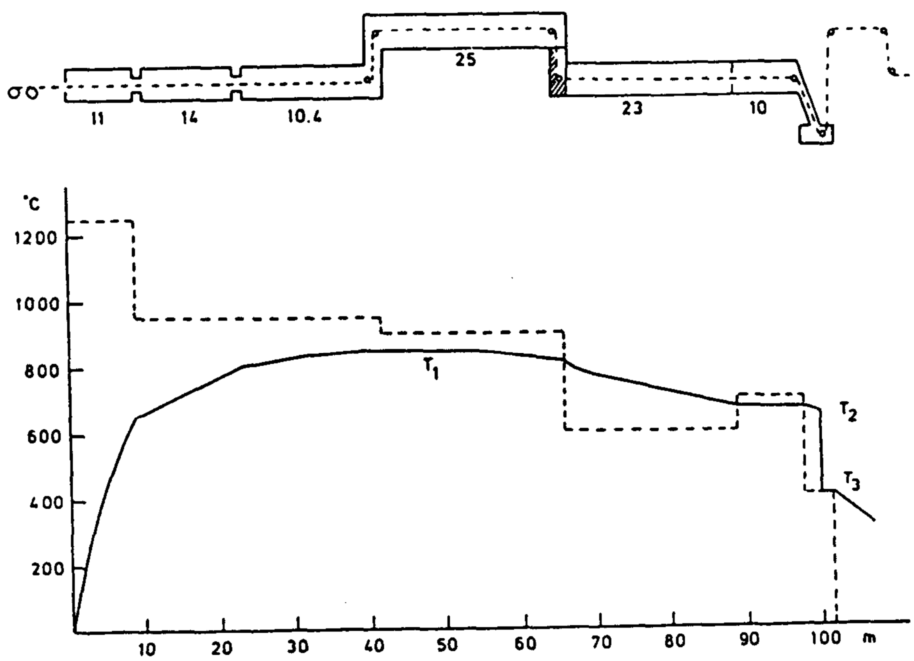


Fig. 3 The average thermal cycle during the ZINQUENCH-trial.

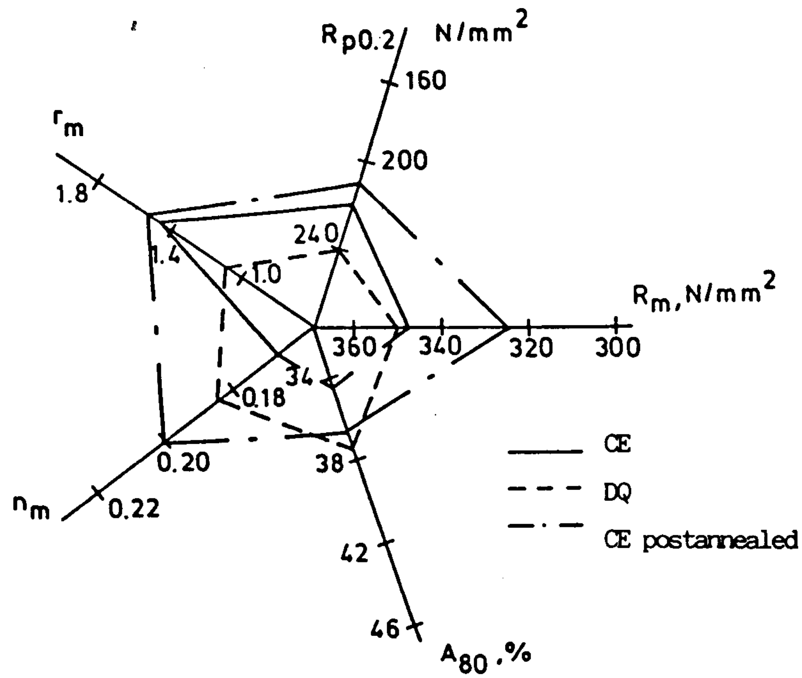


Fig. 4 Properties of the DQ - steel as zinc-quenched and over-aged.

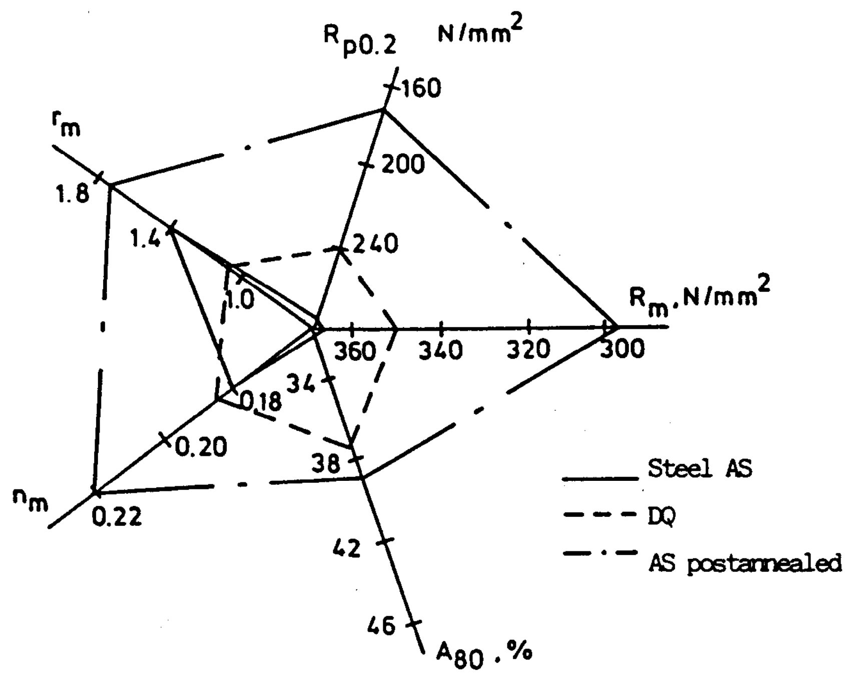


Fig. 5 Properties of the DDQ - steel.

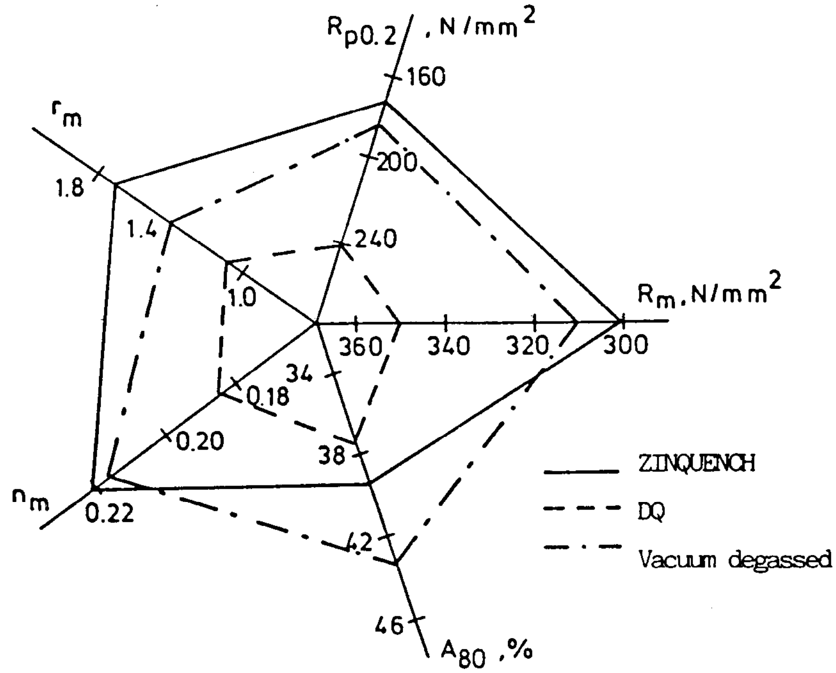


Fig. 6 Properties of the DDQ - steel.

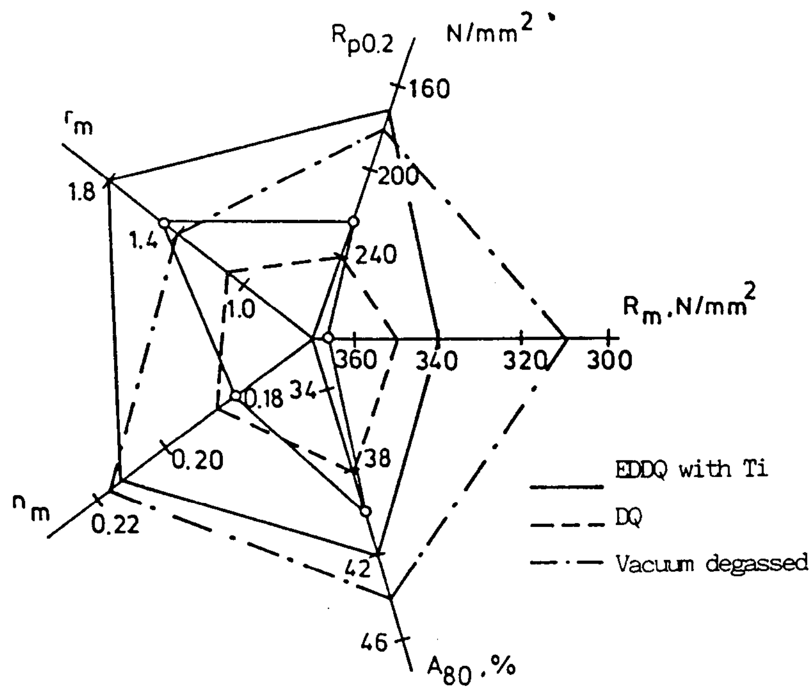


Fig. 7 Comparison of the mechanical properties of DDQ - steels as produced by different methods (interstitial free+ Ti, vacuum degassed).

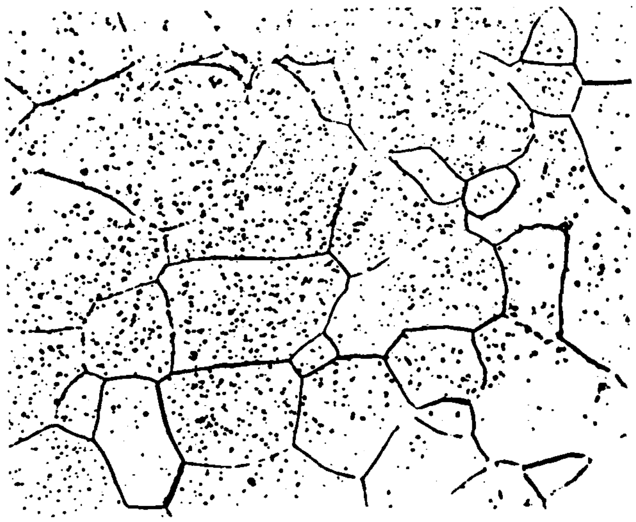


Fig. 8 Carbide precipitation after zinc-quenching and over-aging.

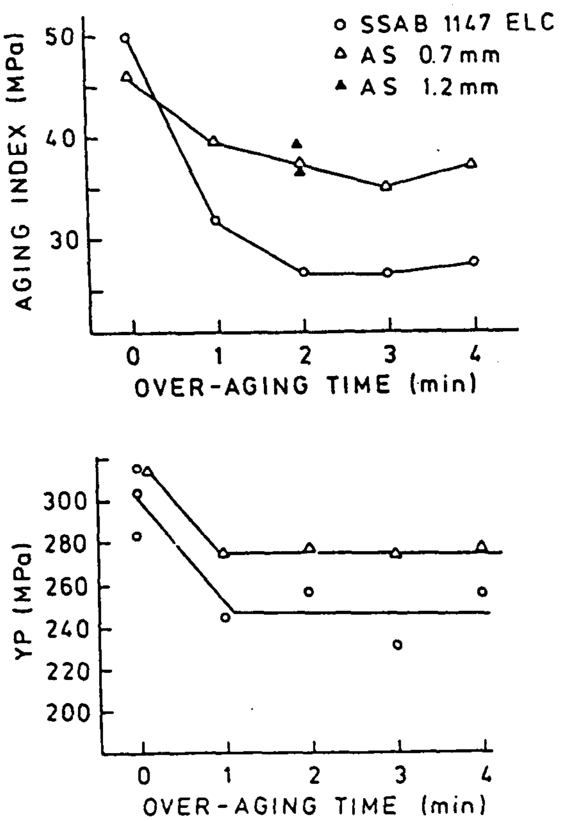


Fig. 9 Effect of over-aging at 350 °C on the ageing index and yield strength.

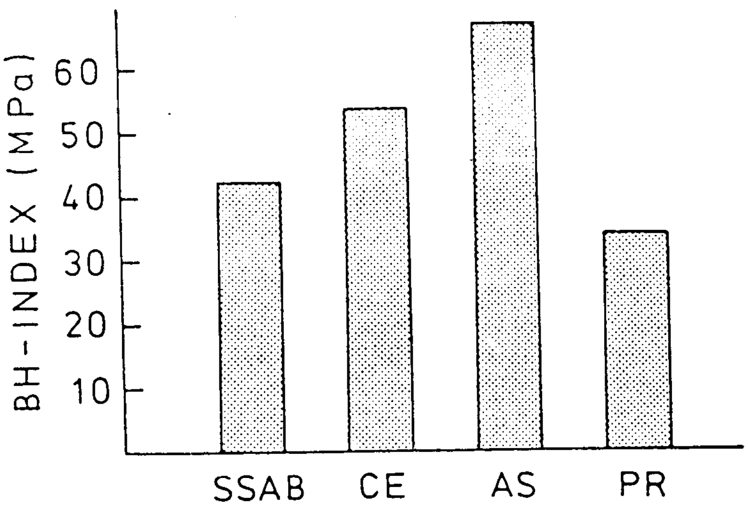


Fig. 10 Bake-hardening effect measured at 2.0 % strain after baking of 20 min at 170 °C.

E R R A T A

TABLE I ; N and Si are % (10^{-2})
steel CE , HCT °C 700

Fig.4 ; --- DQ is produced by the conventional hot-dip galvanizing (SENDZIMIR)

Fig. 5 and Fig. 6 ; --DQ like Fig.4

Fig. 7 ; The steels are annealed by the conventional hot-dip method

April 21, 1986

RESINOGALFAN (Paint coated Galfan)

Kawatetsu Galvanizing Co.,Ltd.

Keiji Okano

In 1953, Kawatetsu Galvanizing Co. began to produce paint coated hot dip galvanized steel sheet as a pioneer of this industry in Japan, and has been expanding the scale of the production to date.

RESINO steel sheet, which is the trade name of paint coated galvanized steel sheet produced by the company, have been winning a high reputation from not only domestic customers but also from foreign users whom the company has been enjoying strong sales.

The principal market of paint coated steel sheets in japan is that for exterior construction materials, such as roofing, side wall,and so forth. However, in recent years, there is an attempt to expand the demand for these products to the market of household electric appriances, office automation equipment, and interior works.

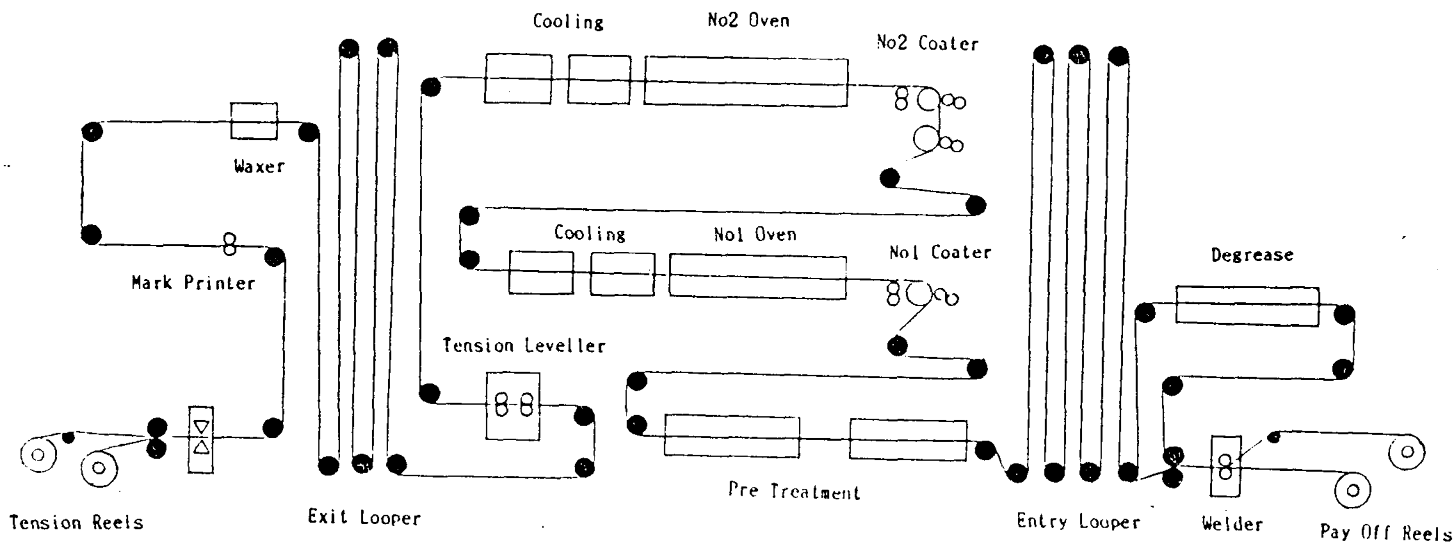
As regards the quality of exterior construction materials, elevation of the durability has been strongly demanded by the market. Under such the backgrnd, we developed RESINOGALFAN in August 1984, This is a paint coated steel sheet using GALFAN as substrate which has superior durability compared with conventional galvanized sheet.

As a result of our positive activities for sales of RESINOGALFAN, the quantity of its production has remarkably increased.

CONTINUOUS COLOR LINE CAPACITY OF KAWATETSU GALVANIZING CO.

	CHIBA WORKS		TAMASHIMA WORKS
	No.2 LINE	No.3 LINE	NO.1 LINE
CAPACITY (T/M)	4,500	14,000	9600
THICKNESS (mm)	0.23～1.2	0.2～1.6	0.25～1.4
WIDTH (mm)	610～1,230	610～1,600	610～1,270
COIL WEIGHT	MAX. 10T	MAX. 20T	MAX. 16T

No3 Color Coating Line



RESINO GALFAN PERFORMANCE

Specimen   Thickness : 0. 35mm
Paint   : Primer, Epoxy
Topcoat, Polyester
(Color, Blue)

Item	Result	Note
Film adhesion		
(a) Cross hatched Erichsen	5	
(b) Ball impact	5	½×500g×50cm
(c) 180° Bend 0T	4	
1T	5	
2T	5	
Gloss	26.7	60° Specular gloss
Pencil hardness	2 H	
Salt spray test 1500Hr.		5% NaCl, 35℃, JIS Z 2371.
Flat	5	
Cross cut	4	
Humidity test 1000Hr.	5	49℃±1 ℃
Chemical resistance		
(a) 5% HCl 50Hr.	5	
(b) 5% NaOH 50Hr.	5	
Dew cycle weathermeter 500Hr.		
ΔE	3.66	ΔE : L, a, b, Color change
G.R %	10.0	G.R : Gloss retention
Out door exposure 1Year		Sea shore
ΔE	1.67	
G R %	72.4	
Blister Edge	No change	
Cross cut	No change	

Raiting : 5 Excellent ~ 1 Poor

PREPAINTING TRIAL WORK ON GALFAN®

◆ SUMITOMO METAL INOUSTRIES, LTD.

MATERIALS EVALUATED

	COATING WEIGHT (g/m^2)	AI CONTENT (%)
GALFAN®	261	4.9
GALVANIZED	258	0.2
GALVANIZED	281	0.2

COIL COATING PROCEDURE

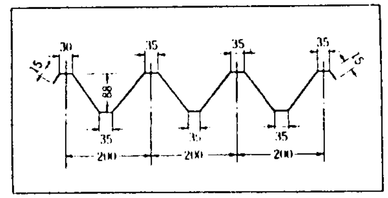
BRUSHING
↓
SURFACE CONDITIONING ………… Pn Z
↓
PHOSPHATING ………… Bt #3,300 60~70℃
TA 18pt
↓
WATER RINSING
↓
CHROMIC ACID RINSING ………… Pn #62 40℃
↓
PRIME COATING ………… Epoxy 3 or 4 μm
↓
BAKING ………… 200℃ × 20~30'
↓
TOP COATING ………… Polyester 10μm or
Silicon-Polyester 14μm
↓
BAKING 210~230℃ × 35~45'

TEST PANEL PREPARATION

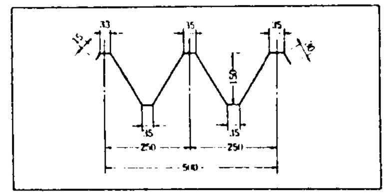
(1) 90° BEND

(2) ROLL-FORMING

TYPE D88



TYPE D150



CYCLIC CORROSION TEST

→ SST → DRY → HUMIDITY →

SST	DRY	HUMIDITY
35℃ × 2H	50℃ × 16H	50℃ × 6H, RH ≥ 98%

NEW ZEALAND STEEL PRESENTATION

1.) 4 Year Exposure Data

- Geothermal
- Severe Marine

Report by D. Christrian giving details of test results to date.

Graphically illustrated in overhead projection. In both cases, GALFAN is corroding at half the rate of galvanized.

For the painted panels at the severe marine site, GALFAN is visually almost unaffected while the galvanized panels with the equivalent paint systems exhibit white rusting at the tension bend and greater cut edge creep corrosion.

To date, the best paint system appears to be a waterborne one.

2.) Soldering

A number of different flux and alloys have been trialed with the most promising results being achieved with 70 Sn-30 Zn alloy and an aluminum soldering flux. Furhter trials with different alloys will be undertaken and accelerated and natural exposure testing undertaken.

Details are in the handout.

3.) Market Activities

Approximately 100T of GALFAN has now been distributed on the N.Z. market, approximately 50% chromated, the remainder painted. Market response has been very positive.

I will just mention a few points.

a.) Patina

There has been no adverse reaction to the short time for patina formation or the darkness of the color. In fact, this has been a positive selling point as the new galvanized coil causes bad sun reflections which are a cause for concern for some manufacturers.

b.) White Rust

GALFAN appears to be as susceptible to white rust as bath in both oiled and chromated conditions.

c.) Roll Forming

In a couple of cases when rollforming trapezoidal shapes metal pickup on the work rolls has occurred. This has occurred only a few meters was run and effectively ruined the sheet through pickup and midentation.

On normal corrugated feed these was evidence of slight scuffing of the surface but no pickup.

d.) Pressed Metal Tiles

This represents about 15% of the New Zealand market for galvanized coil and is used in both painted and unpainted form. The main selling point is coating ductility. An example of the tiles pressed from chromated coil is shown in the slide.

e.) Insulated Panel Feed

We have recently supplied some painted material for insulated panel feed but have not had any feedback yet.

f.) Farm Buildings

Quite a number of test panels have been put into farm buildings as shown in this slide. Although just put in the GALFAN sheet is only visible at certain samples.

g.) Domestic Housing

GALFAN has been used for domestic roofs and in one case the house is 200 meters from the surf and has normal galvanized flashings, lead edge ridging and a number of features which make it a very good test bed.

Steel based roofs for domestic houses is approximately 50% of total market and thus represent a significant proportion of our galvanized product range.

Paints we wish to inquire about are:

- Developments in Grade E production.

- Any others have had problems with
  - roll forming
  - pressing
  - skinpassing
  - fretting

- Any further developments in
  - soldering
  - edge roughness flicking
  - cratering
  - grain boundary depression

- Could we have an idea of the set of guarantees that are being used at present.

GALFAN SOLDERING

After a number of attempts we have found a successful system for soldering Galfan. This is still being worked on and panels are being prepared for accelerated and natural exposure testing.

The solder that has proven to be most successful is known in New Zealand as AL-7. Other alloys to be trialled are AL-4 and AL-3. The alloy analyses are:-

	Sn	Zn	Pb
AL-7	70	30	-
AL-4	80	20	-
AL-3	39	2	59

The most suitable flux has been one developed for soldering Aluminium and other alloys.

It is a proprietry flux produced by

FARMAC ENTERPRISES LTD
6B/59 Victoria Street
Onehunga
AUCKLAND 6

Ph: (06) 668186

For further information on the flux we suggest you contact the manufacturers.

New Zealand Steel Limited

MEMORANDUM

FILE:

TO: Dr N. Clark ,

FROM: D. Christian

SUBJECT: PERFORMANCE OF PREPAINTED AND UNPAINTED GALFAN TEST PANELS IN CORROSIVE ENVIRONMENTS:

DATE: 17 April 1986

The following are the results of exposure studies to date at our severe marine and geothermal (hydrogen sulphide atmosphere) test sites.

The test panels measure 200mm x 150mm and have a triangular fold, which has a 1.3mm internal radius at the apex, together with a scribe through the zinc coating.

Performance Unpainted

After four years the zinc-aluminium coating of unpainted Galfan is corroding at half the rate of galvanised steel at both test sites.

	Weight Loss Upper Surface [a] g/m^2			
	Severe Marine		Geothermal	
Exposure Time (Years)	Galvanised Steel	Galfan	Galvanised Steel	Galfan
1	12	-	-	-
2	22	10	102	56
3	-	15	150[b]	81
4	68	24	-	112
5	85	-	-	-

NOTES: a = The original zinc coating weights on the upper surfaces were approximately 200 g/m^2.

b = 90% panel face red rust.

The corrosion rate of the skyward surface of galvanised steel at the severe marine site has varied in the range 11 to 17 $g/m^2/y$ (4 measurements), and at the geothermal site in the range 50 to 53 $g/m^2/y$ (3 measurements).

The corrosion rate of the skyward surface of galfan at the severe marine site has varied in the range 5 to 6 $g/m^2/y$ (3 measurements) and at the geothermal site in the range 27 to 28 $g/m^2/y$ (3 measurements).

The test panels of galvanised steel with 200g/m^2 per surface had 90% red rust on them at the geothermal site after three years which was equivalent to the condition of a galfan sample with a 100g/m^2 coating weight on the exterior surface.

Cont..../2

Severe Marine Performance Prepainted

After four years exposure, prepainted Galfan is visually almost unaffected. No white rusting is visible at the tension bend and there is only 3mm cut edge creep corrosion. The galvanised steel samples, prepainted with equivalent paint systems, exhibit white rusting at the tension bend and 5mm cut edge creep corrosion.

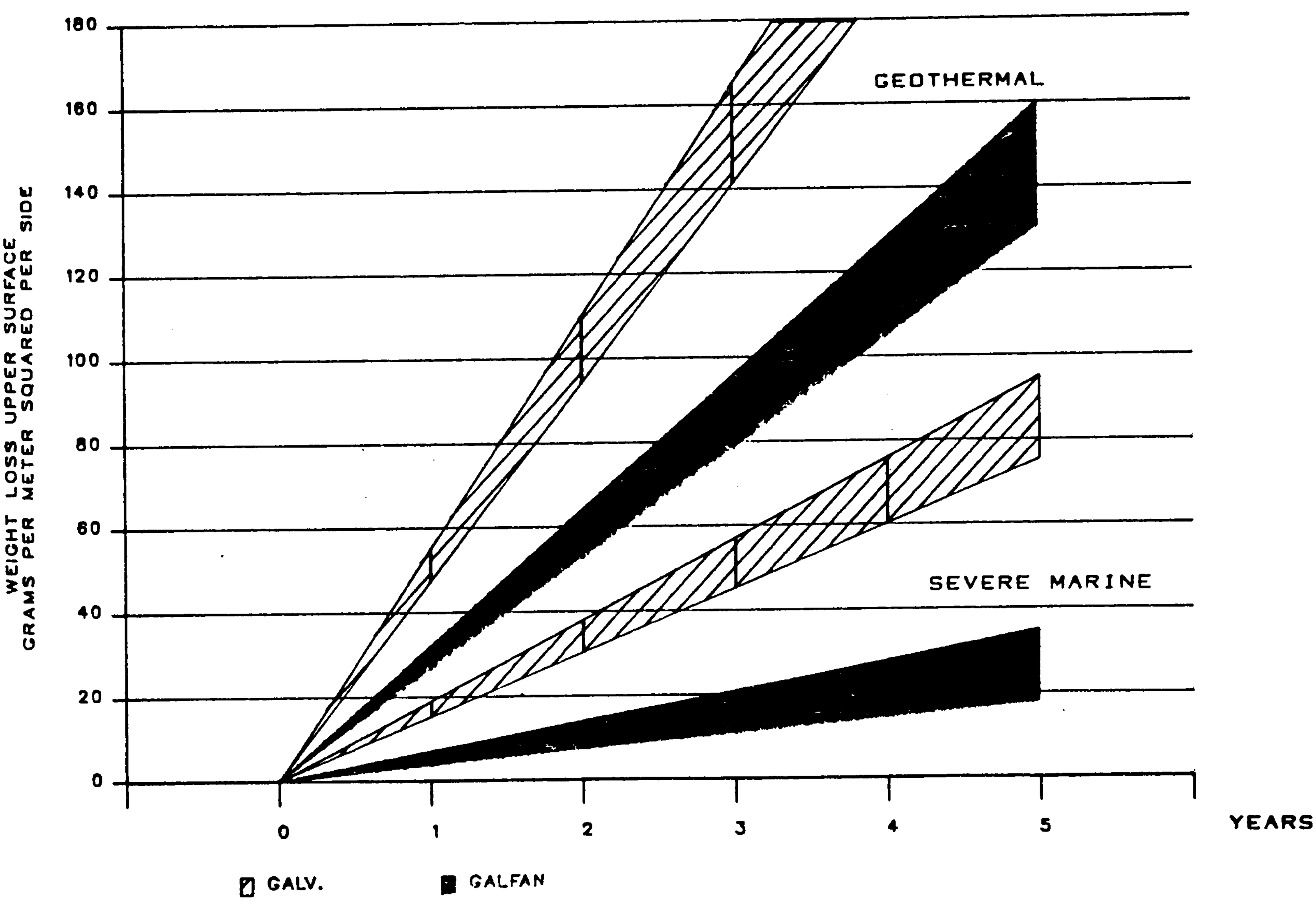
Paint systems under trial are:-

SMP on epoxy primer
Polyester on epoxy primer
Waterborne Acrylic on water based primer

The waterborne system appears best at this stage.

D. F. Christian
Coated Products Technical Manager

EXPOSURE TEST RESULTS AT SEVERE MARINE AND GEOTHERMAL TEST SITES IN NZ



April 21, 1986

MARKETING REPORT OF YODOGALFAN

YODOGAWA STEEL WORKS, LTD

As the first maker in the world to market YODOGALFAN commercially, we established our sales policy which proved to be very successful and I should be happy if you would find my presentation valuable for your future marketing strategy.

First of all, YODOGAWA is not an integrated mill and it has been our unchanged philosophy to always develop value added products to reinforce our standing among steel industry and at the same time, to grow healthily. Today, although, sale of galvanized and pre-paited products is growing part of our business, we have, what we call, in-house customer, our building material division, where we manufacture various building materials including roofing and siding panels, other exterior goods and home appliances. This division is, as a matter of fact, the largest consumer of our galvanized and prepainted steel products.

When we marketed YODOGALFAN, we made it as our basic sales policy to sell it as prepainted with the brand name, YODOGALFAN-COLOR. By selling as painted, we could add considerable value to it and established an excellent image of new coated steel, GALFAN.

Secondly, in sales promotion, we emphasized its superb corrosion resistance and excellent formability and especially, to give our customer, security on the quality of the newly developed products, we have introduced 10 year guarantee agaist red rust for the first time in Japan. Among steel industry, it was not common to guarntee for performance of any products in Japan and therefore, our first attempt to introduce the product with guarantee has been accepted in the market place very smoothly with a fresh impression.

Thirdly, as you might know, we distribute our products through dealers and trading firms and we seldom go direct to our customers. When we started marketing of YODOGALFAN, we had to make the product attractive to these dealers as well. For this purpose, we introduced very strict list price system. Under this system, our dealers could secure reasonable full mark-up and it encouraged promotional efforts of our dealers.

Lastly, about our targetted market, in view of the fact that roofing and siding application is still major market for pre-paited steel in Japan, we have been concentrating our efforts in this area.

Our next assignment would be to develop new applications for both bare and prepainted YODOGALFAN in other area than exterior application and we are quite confident that we can develop other market especially for its superior formability.

ZALAS
Zinc and Lead Asian Service

95 Collins Street Melbourne
Victoria Australia 3000
Telephone 654 1611 Telex AA38806

GALFAN IN ASIA

MARKETING PLAN FROM ZALAS

Target Markets

ZALAS is responsible for technical assistance and market development services in East and South Asia excluding Japan. This area can be conveniently divided into four groupings each with unique factors applying.

In order of potential these are:

1. China
2. South Korea
3. Taiwan
4. ASEAN Region

The galvanizing sector is at a distinctly different stage of development in each of the four regions:

China

Coil Galvanizing

China operates a continuous coil galvanizing line at Wuhan. The line was ordered in 1974 from West Germany, started up in 1978 and has a capacity of 240 000 tonnes p.a. of galvanized product. Strip width is 1.7 metres. It was announced in December 1985 that Wuhan Iron & Steel placed an order for a colour coating line with Davey-McKee with a capacity of 60 000 tonnes p.a. During Dr. Goodwin's recent visit to China, it was mentioned that another galvanizing line would be built in three years.

An announcement was made recently that stage II of the Baoshan Steel Works near Shanghai would double capacity to 6 million tonnes p.a. and the product range would be extended to include cold rolled continuously galvanized and colour coated coil. Schloemann Siemag have the contract for the cold rolling mill.

The biggest steel works in China is at Anshan which is raising its capacity to 9 million tonnes and already has cold rolling facilities.

There are many cut sheet galvanizing lines utilising the lead/zinc process operating throughout China.

Galvanized pipe plants operate throughout China and are generally believed to be mostly of the batch type where tubes are immersed in bundles rather than being conveyed continuously through the line. A modern pipe galvanizing plant set up as a joint venture with Italian interests is now operating in an industrial zone in from Macao.

Wire galvanizing is also undertaken throughout China with Tianjin being the principal centre for wire galvanizing, with around one third of China's total capacity.

It is estimated that the galvanizing industry in China consumes 130 to 150 000 tonnes of zinc p.a.

South Korea

South Korea has a number of modern continous coil coating lines of the Sendzimir type located in Seoul and Pusan. The pipe galvanizing sector is large and well established with modern equipment. The zinc consumption of the galvanizing sector is estimated at 60 to 70 000 tonnes p.a.

ASEAN Region

Coil galvanizing in the ASEAN Region is characterised by the use of mini galvanizing lines all of around 50 000 tonnes p.a. product capacity. Three lines are established in Indonesia, three lines in Malaysia, and one each in Thailand and the Philippines. The remaining sheet galvanizing are of the lead/zinc process and well established in all these countries. Pipe and wire galvanizing are also important and with few exceptions generally of the mediocre standard. Zinc consumption for galvanizing in the ASEAN Region is estimated to be in excesss of 100 000 tonnes.

Taiwan

Up until recent times the sheet galvanizing sector in Taiwan consisted of ageing lead/zinc process pot lines. Early in 1986 the CRA subsidiary, Conzinc Asia Holdings, took up a share in the Taiwan company An Mau Steel and plan to install a continuous coating line to produce Galvalume. Start up is planned for early 1987 with a capacity of 200 000 t.p.a. of product consuming 6 000 t.p.a. zinc. The facility will also include a colour coating line. Taiwan has significant pipe and wire galvanizing facilities and their zinc consumption for galvanizing is estimated at 30 000 tonnes p.a.

DEMAND

Looking at each of the four market areas:

China

The Chinese market is difficult to predict as the centrally planned economy means our success will depend on technocratic rather than market criteria. The Ministry of Metallurgical Industry will determine the coating process, stipulate the factory, and allocate the output.

Our judgement at this stage is that the Chinese will most likely adopt Galfan or Galvalume technology and plan on installing a line of around 150 000 tonnes capacity every two years. The other option that seems less likely but more logical is for them to adopt the mini-line route installing a larger number of smaller lines of around 50 000 tonnes capacity throughout China. This option may not appeal to them because of their preference for "high technology" even though the mini-line option would overcome transportation and distribution problems.

The output in China will be for domestic consumption and we do not see them exporting in the planned period.

Strong interest has been show by the wire industry in Galfan technology as a means of increasing the corrosion performance of the product.

South Korea

South Korea is a very export oriented producer and believe they see Galfan as a means of broadening their product range in order to remain world competitive. Galfan will replace existing galvanizing markets with some additional volume taken from other coatings. Union Steel have Galvalume capacity coming on-line this year.

ASEAN Region

The galvanized sheet and coil producers in the ASEAN Region use the lead/zinc process which does not lend itself to Galfan conversion. The current level of installed capacity coupled with the current economic climate caused by drops in oil, tin and rubber prices makes the chances of introduction of Galfan to be unlikely in this area inside three years.

Taiwan

As already mentioned, Taiwan have decided to introduce a Galvalume line with an output of in excess of domestic requirements. Further expansions of this facility could include Galfan.

DEMAND ELASTICITY

China

The current situation in China is that limitations to growth of coated products are central allocation of capital and resources by the Government. It is a country which economy demands bears little relationship to production and as such predictions for future growth are not possible.

South Korea

South Korea is export oriented and demand elasticity there will depend much on the growth and the economies of their trading partners and their ability to remain overall competitive. On past performance their thrust will be to install capacity and then use the production pressure to make them take an entrepreneurial attitude to finding markets.

GOVERNMENT POLICIES

There are no foreseeable Government restrictions or policies which impinge on our ability to have Galfan accepted in any of the four regions under consideration.

MARKET AWARENESS

China

Seminars play an important role in convincing the Chinese that products or equipment of interest of them involve the latest technology and represents the best available. Plans are in hand to follow up previous meetings between ILZRO and the Ministry of Metgallurgical Industry in the latter part of April 1986. A number of key people within the Ministry are aware of Galfan and other competitive coatings. Further efforts will be made to convey awareness to engineers of influence further down the line as well as convey the technological advantages to personnel at existing and potential operating sites.

South Korea

Korea Zinc Company as the sole zinc producer in South Korea are keen to provide support for the introduction of Galfan technology to their local industry. Arrangements are proceeding following up an earlier ILZRO visit to this country with emphasis not only on the technical benefits to the producers but also aimed at export and marketing personnel.

ASEAN & Taiwan

Apart from [illegible] there appears to be little prospect for [illegible], it is planned to promote awareness of [illegible] areas for future development. [illegible] means of achieving [illegible] paper to, and participation [illegible] Steel Institute meetings [illegible] all potential licencees. [illegible] proposed for the next but one [illegible] May 1987 in Bangkok.

LITERATURE

Technical

The basic [illegible] Galfan Galvanized Alloy and Technology [illegible]. This will be made available in English only to [illegible] technicians throughout the area [illegible] interpreting, and using technical data [illegible].

The [illegible] Progress Report [illegible] minutes of the various Galfan Licencees' meetings will be valuable references to detail information for seminar leaders.

The ILZRO Galfan manual is now two year old and need updating, particularly in Section V - Process Technology . The Asian markets being dealt with are well informed, intelligent, and require reliable and credible information on which to base their decision making.

Product

A product brochure describing the benefits to the producer from the point of view of production benefits and product advantages has been prepared for publication in English and Chinese with provision for Korean text to be run on later. This brochure will be used to assist with Galfan awareness and project the coating as modern and upmarket.

ZALAS

Zinc and Lead Asian Service (ZALAS) is a market development association of lead and zinc producers. Providing technical assistance and market development services to sustain and develop existing and new applications containing zinc products. ZALAS provides a range of free services including technical consultation, publications, technical literature, [illegible] services and the organisation of [illegible] seminars and workshops [illegible] ZALAS does not produce, sell or trade in zinc metal or [illegible]

[illegible]

[illegible] Ltd (Canada)
[illegible] Zinc Company of Australasia Ltd (Australia)
Mount Isa Mines Ltd (Australia)
Noranda Sales Corporation Ltd (Canada)
Sulphide Corporation Pty Ltd (Australia)
Zinc Development Association (United Kingdom)
Padaeng Industry Co Ltd (Thailand).

Zinc and Lead Asian Service,
5th Floor, 124 Exhibition Street,
Melbourne, Victoria 3000.
Telephone: (613) 654 1611.
Telex: AA38806.

International Lead Zinc Research Organization (ILZRO)

Founded in 1958, the US based International Lead Zinc Research Organization, with 30 members from 14 countries (including all ZALAS members), forms the research arm of the world's lead and zinc producers. Through ILZRO they have channelled some $US32m to date in research and development projects aimed at improving the end use technology of lead and zinc. Galfan is one of the successful outcomes of such ILZRO research programs.

鋅與鉛亞洲服務(ZALAS)是一個爲鋅、鉛金屬生產商向用戶推廣這兩種金屬的市場發展機構，其主要工作乃是提供技術援助[illegible] [illegible]

[illegible]

[illegible]
[illegible]
[illegible]
[illegible]
英聯邦的鋅發展協會
泰國的Padaeng工業有限公司

ZALAS的地址如下：
Zinc and Lead Asian Service,
5th Fl., 124 Exhibition Street,
Melbourne, Victoria 3000,
Australia.
電話：(613) 654 1611
電訊：AA 38806

國際鉛鋅研究組織 (ILZRO)

在1958年成立。以美國爲根據地的國際鉛鋅研究組織有來自十四個國家的三十個成員(其中包括所有鋅與鉛亞洲服務的成員)，組成全球性的鉛、鋅產品研究網。直到現時爲止，透過ILZRO爲提高鉛和鋅的應用技術而進行的專題研究經費已達三千二百萬美元。"高方"就是ILZRO研究計劃中的一個特出成果。

ZALAS

Zinc and Lead Asian Service
鋅與鉛亞洲服務

12 good reasons for choosing GALFAN

[illegible]高方[illegible]的十二項理由

Galfan is a "second generation" zinc alloy coating for steel – offering not only increased corrosion protection over conventional galvanized, but also unique benefits in production and in the market. Galfan broadens the choice of coatings available to both manufacturer and consumer, and so is better able to match market needs. In brief, the advantages of Galfan are:

"高方"是應用在鋼鐵上的鋅合金鍍層的"第二代"產品——它不單比傳統的熱浸鍍鋅有更好的防腐性能，並且在生產及市場上有獨特的優點。高方能爲生產商及用戶提供多種的鍍層選擇，因此更能適應市場的需求。下面概述高方的各種優點：

GALFAN

In production

1 **Lower initial licence fee**
Galfan's licence fee is very much lower.

2 **No royalty payments**
No costly royalty payments are payable. An initial licence fee is all that is required.

3 **Lower conversion cost**
The cost of converting existing plant to Galfan is much lower. Existing galvanizing lines can be easily adapted

4 **Less critical process control parameters**
A Galfan line allows for broader and less critical process control parameters.

5 **Wider coating weight range**
Galfan allows lighter and heavier coating weights to be used, thus widening the range available.

6 **Less energy**
The lower line operating temperatures of Galfan reduces energy requirements.

高方®

在生產方面

1 **只需極低的專利權費**
高方的專利權費用很低。

2 **無需專利費**
只需支付最初的專利權費,以後不必另繳年費。

3 **改裝費用低廉**
更改現有裝備爲高方裝置所費極微,一般的熱浸鍍鋅生產線很容易就可以改裝。

4 **工藝參數廣闊**
高方的生產線可容許較寬的工藝參數。

5 **塗層重量範圍寬容**
高方容許較輕或較重的塗層重量,故此應用範圍廣泛。

6 **節省能源**
高方的生產線使用較低的操作溫度,故此節省能源。

GALFAN

In the market

1 **Longer life**
Galfan offers a longer life than conventional galvanized.

2 **Superior forming**
Galfan has superior forming properties, particularly with reverse bending and deep drawing.

3 **Paintability**
Galfan offers an improved adhesion and better paint performance for coil coating.

4 **Suited to heavier gauge steel**
Galfan, with better cut-edge performance, is better suited to heavier gauge steel due to its high zinc content.

5 **Weldable and Solderable**
Galfan is readily spot welded and soldered.

6 **Suitable with Concrete**
Galfan is suited for applications requiring contact with concrete, such as in concrete formwork.

高方®

在市場方面

1 **壽命更長久**
高方比傳統的熱浸鍍鋅有更長的保護作用。

2 **優良的成型特性**
高方有更好的成型加工性能,尤其是在往復彎曲及深孔冷擠成型上。

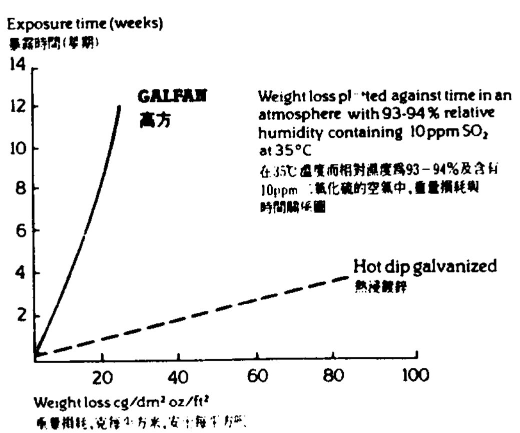
3 **塗漆性能**
高方有更好的附著性,對於滾輪塗漆有更佳的可塗性能。

4 **對厚截面鋼材的適應性**
由於高方有高的含鋅量,其切口性能較佳,故此對於厚截面鋼材亦甚適宜。

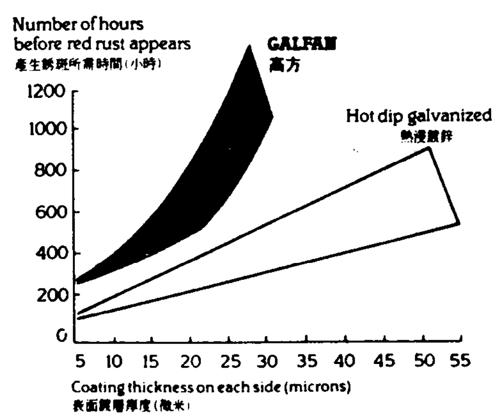
5 **焊接性能**
高方適宜於點焊及錫焊。

6 **對混凝土的適應性**
對於要與混凝土接觸,例如混凝土構架等的應用,高方也極適宜。

Resistance to humid atmospheres containing sulphur dioxide (SO_2)
在含有二氧化硫(SO_2)的空氣中的耐蝕性



Resistance to salt spray 5% NaCl
對鹽霧試驗(含5%氯化鈉)之抗腐性



THE SCHEDULE FOR OBSERVATION

of Kawatetsu Galvanizing Co. Ltd., Chiba Works

Dear Galfan Licensees, thank you so much for your coming.

April 22, 1986

	8°00′ a.m.	departure	Tokyo Prince Hotel
	8°20′ a.m.	departure	The Imperial Hotel
	10°00′ a.m.	arrival	Kawatetsu Galvanizing Co. Ltd., Chiba Works
from	10°05′ a.m.		Explanation of Outline of Chiba Works (at council room)

Compliments : Shoichi Murakami (General Superintendent, Chiba Works)

Explanation : Tadakuni Mori (Assistant General Manager, Technical Control Dept., Chiba Works

from	10°20′ a.m.		Observation of Chiba Works (No.3 CGL→No.3 CRL)

CGL = Continuous Galvanizing Line

CRL = Continuous Paint Coating Line

The "R" in "CRL" means "Resino" which is the trade name of paint-coated galvanized steel sheets and coils produced by Kawatetsu Galvanizing Co. Ltd.

	11°10′ a.m.	departure	Chiba Works (starting from the exit of 3CRL, doing not return to the council room)
	11°15′ a.m.	arrival	Discussion and lunch hall (Tamahimeden) Coffee break
from	11°25′ a.m.		Discussion (Questions and Answers)
from	11°45′ a.m.		Lunch
	1°00′ p.m.	departure	Tamahimeden
	2°30′ p.m.	stopping	over at The Imperial Hotel
	2°50′ p.m.	stopping	over at Tokyo Prince Hotel
	4°00′ p.m.	arrival	Haneda Air-Port

Flight : ANA 683 5°35′ p.m. departure (for Hiroshima)
ANA 685 6°30′ p.m. departure (for Hiroshima)

Good luck to you !

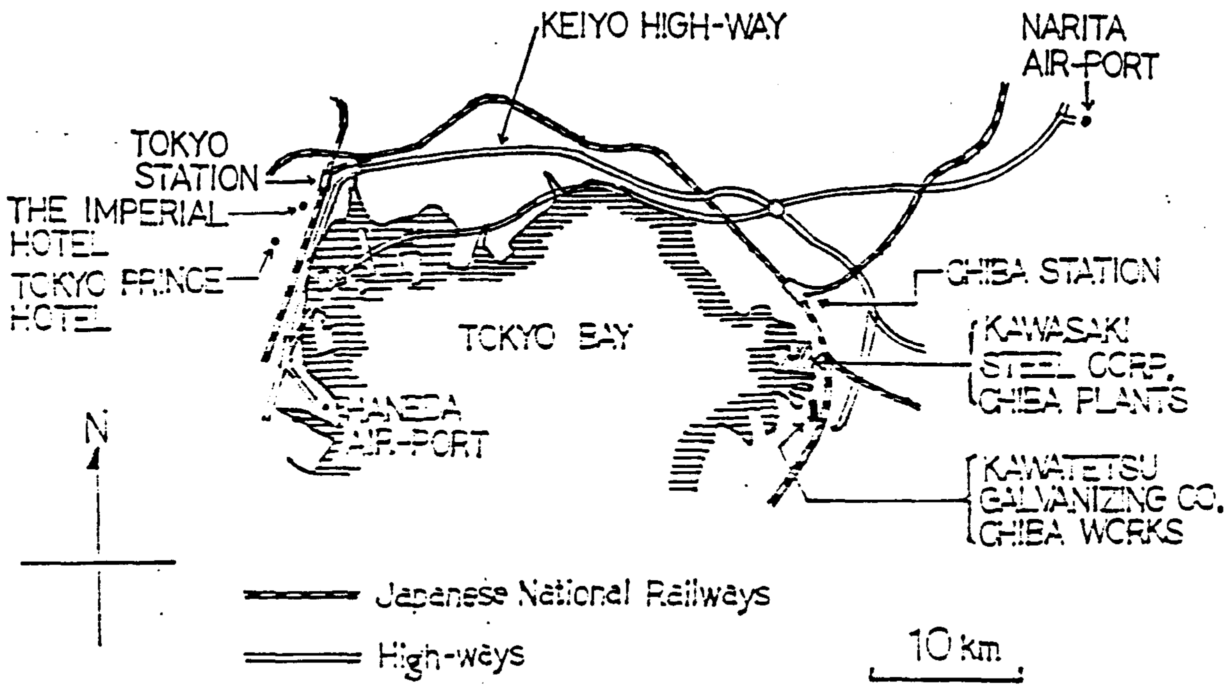
(Produced by : Kawatetsu Galvanizing Co. Ltd., Technical Control Section K. Tsumura)

An Outline of Chiba-Shi (City)

Chiba-Shi is about 40km distance to the east from Tokyo. It takes about 35 minutes by a limited express train from Tokyo to Chiba-Station. Its population at September 1984 is about 780.000.

At 1951, Kawasaki Steel Corporation began construction of a new iron- and steel-making plant in the south of Chiba-Shi. It is the first iron- and steel-making plant constructed after the World War II in Japan. The construction became the start that not only Chiba-Shi but also Chiba-Ken (Prefecture), which had been agricultural and fishing region, were transformed into industrial region.

At other side, Chiba-Shi is the one of bedroom-towns of Tokyo. You can see many collective housing areas in the city. Therefore, the population is increasing rapidly.

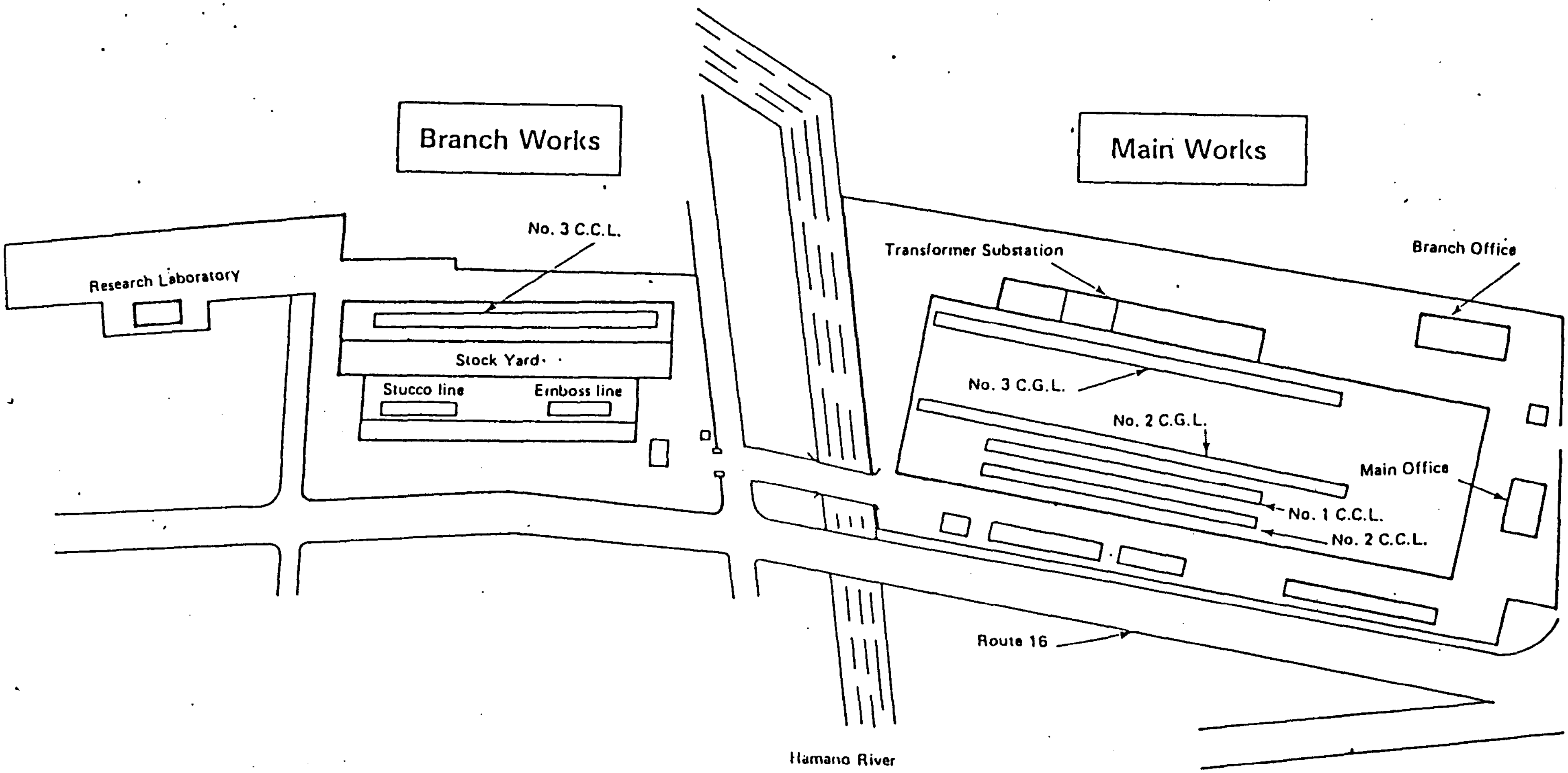


KAWATETSU GALVANIZING CO., LTD.

Chiba Works

— 1985 —

GENERAL ARRANGEMENT (CHIBA WORKS)



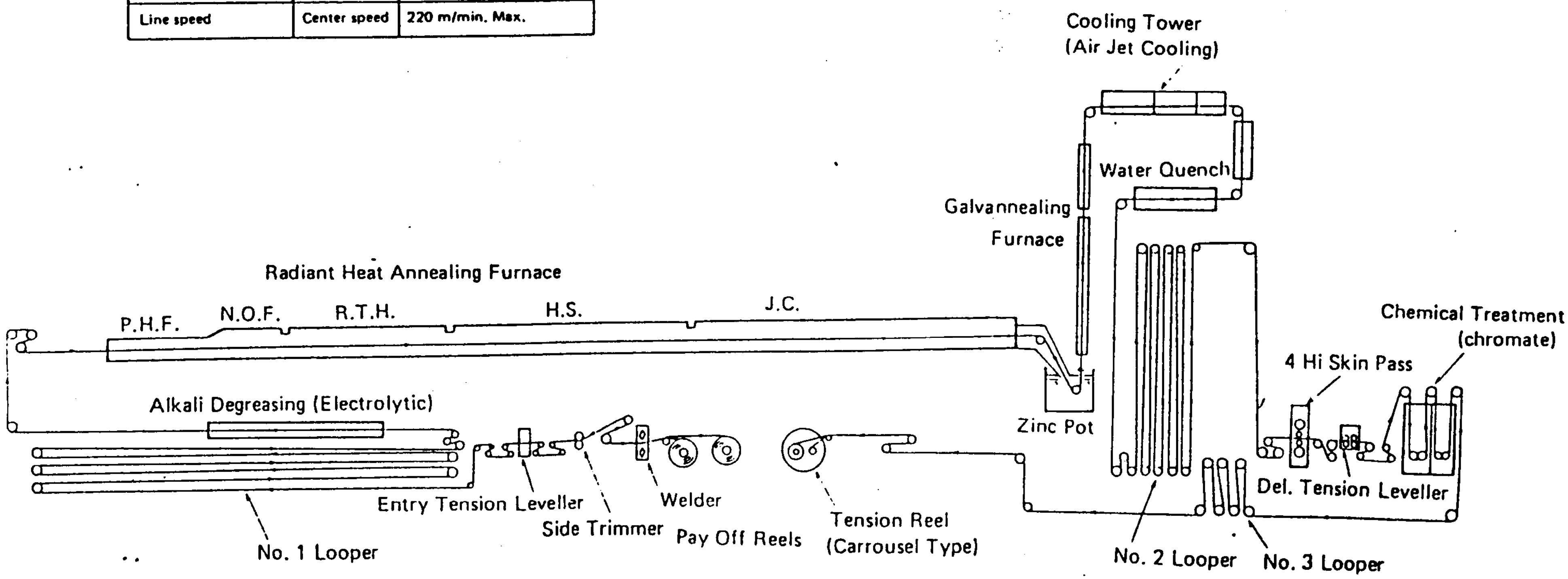
MAIN PRODUCTION EQUIPMENTS (CHIBA WORKS)

		Continuous Hot Dip Galvanizing Lines		Shearing Line	Continuous Color Coating Lines		Emboss Line	Stucco Line
		No. 2	No. 3		No. 2	No. 3		
Establishment		Oct. 1969	Jun. 1981	Aug. 1965	Jun. 1967	Aug. 1982	May 1979	Nov. 1979
Production Capacity (Tons/Month)		12,000	20,000	4,000	4,500	14,000	2,500	2,100
Line Speed max. (m/min)		140	220	50	60	150	60	40
Dimensions (mm)	Thickness	0.25 – 3.5	0.23 – 2.3	0.23 – 0.7	0.23 – 1.2	0.2 – 1.6	0.27 – 0.5	0.27 – 0.5
	Width	610 – 1,250	610 – 1,550	610 – 1,000	610 – 1,219	610 – 1,600	914 – 1,000	914 – 1,000
Coil Weight max. (Tons)	Entry	20	42	15	15	22	15	15
	Delivery	13	21	10	10	20	5	5
Note		-------	--------	Cut Sheet length: 1829 – 2438 mm Resino Color Hi-Resino Resilon Resino Print	Cut Sheet length: 1829 – 2438 mm Resino Color Hi-Resino Resilon Resino 20 F	Resino Color Hi-Resino Resino 20 F Zincro Metal (for Automobile)	Embossed Depth 16 – 400 µm	Embossed Depth 16 – 400 µm

NO.3 CONTINUOUS GALVANIZING LINE

LINE SPECIFICATION

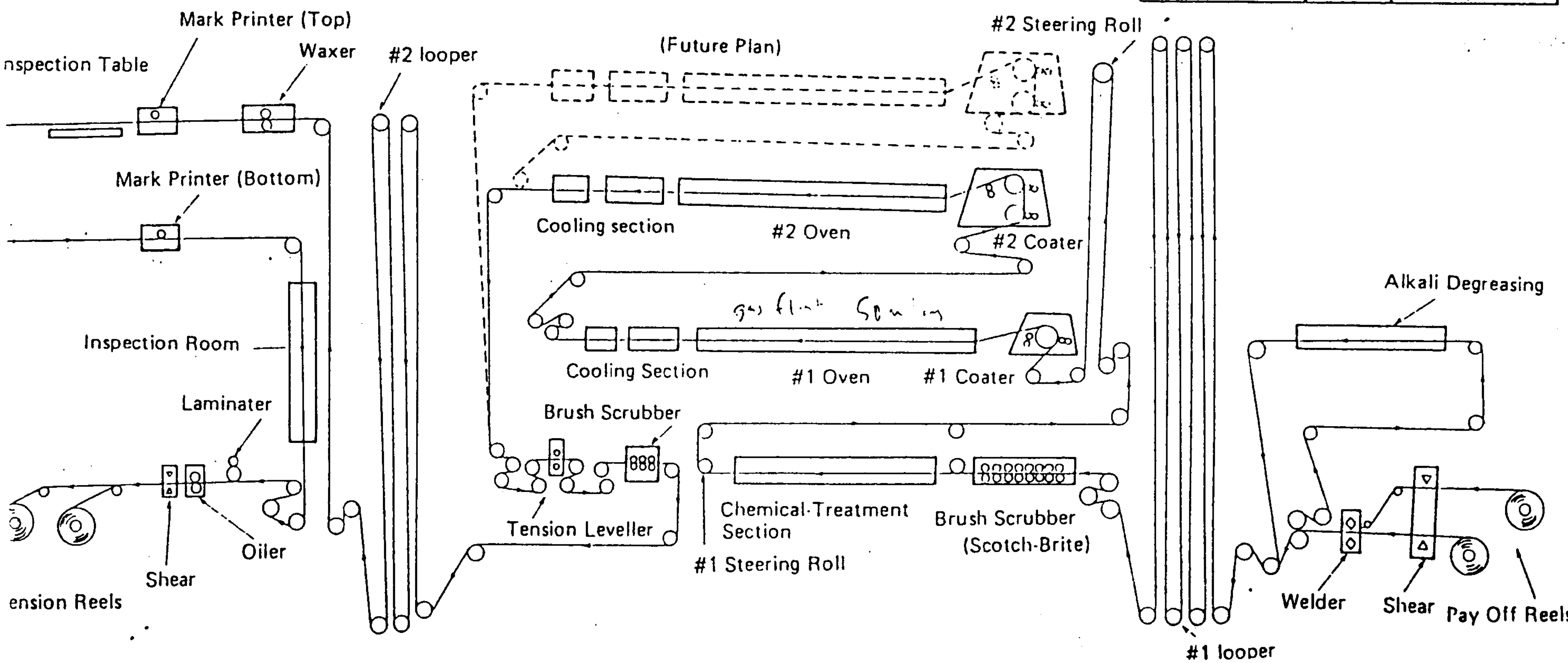
Coil weight	Entry	42 t Max.
	Delivery	21 t Max.
Coil O.D.	Entry	2,600 mmϕ
	Delivery	2,200 mmϕ
Doll I.D.	Entry	419, 508, 610, 660 mmϕ
	Delivery	508, 610 mmϕ
Dimensions	Thickness	0.23 – 2.3 mm
	Width	610 – 1,580 mm
Line speed	Center speed	220 m/min. Max.



NO.3 CONTINUOUS COLOR COATING LINE

LINE SPECIFICATION

Coil weight	Entry	22 ton Max.
	Delivery	20 ton Max.
Coil O.D.	Entry	2,200 mm Max.
	Delivery	2,000 mm Max.
Coil I.D.	Entry	508 mm, 610 mm
	Delivery	508 mm, 610 mm
Dimensions	Thickness	0.2 – 1.6 mm
	Width	610 – 1,600 mm
Line speed	Center speed	150 m/min. (Max.)
Looper storage length	Entry	258 m
	Delivery	150 m

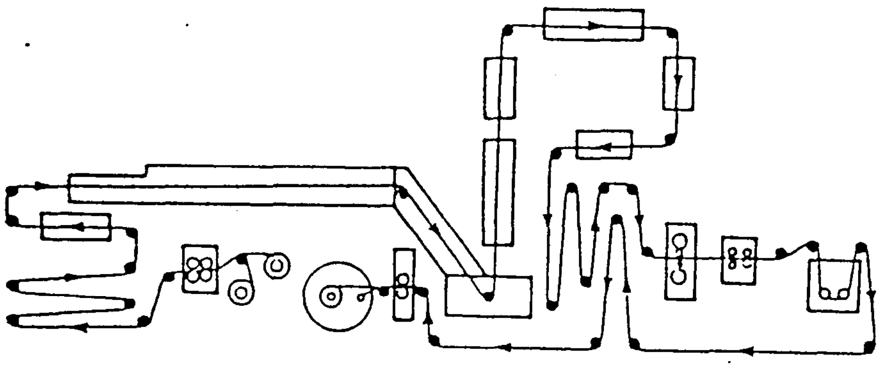


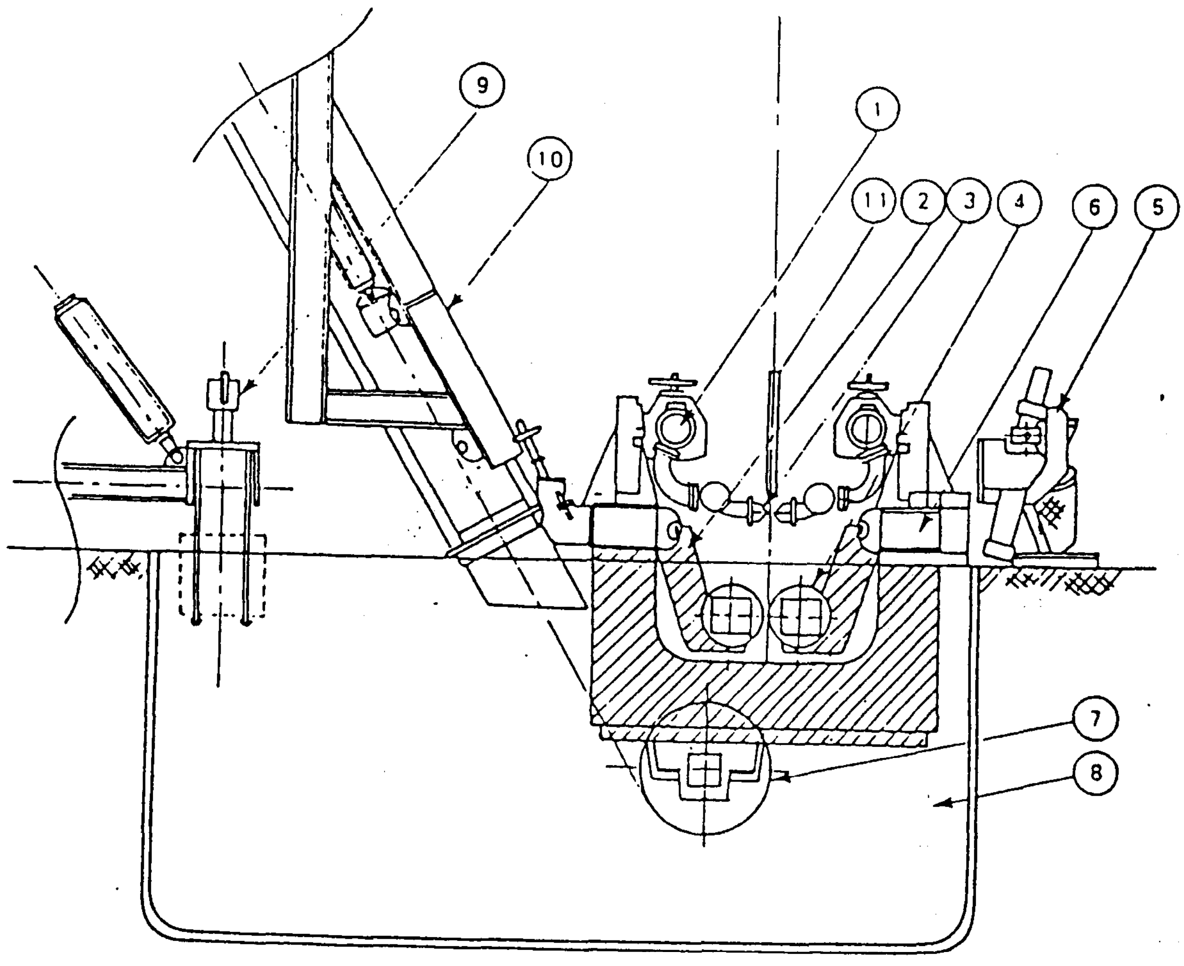
PRODUCT LIST IN CHIBA WORKS – 1

Developed year	Brand Name	Characteristics
1964	Galvanized sheets	30 g/m2 to 610 g/m2 (G165)
1965	Resino color	The first "Prepainted Galvanized Steel sheets" in Japan
1968	Resino print	Two types of print pattern are available – wood & straight grain.
1971	Viny-resino	Vinyl chloride coated steel sheets
1974	Resilon	A silicon polyester resin gives full play to its durability, weathering property and heat-proof property.
1977	Resino emboss	Embossed resino print.
1979	Resino stucco	A new high-grade exterior material in two-tone color.
1981	Resino 20-F	A vinyl fluoride coat, which is guaranteed for 20 years.
1981	Resino board	Coated steel sheets for a black (green) board with guard film
1981	Colored sheets	Colored sheets directly on cold sheets.

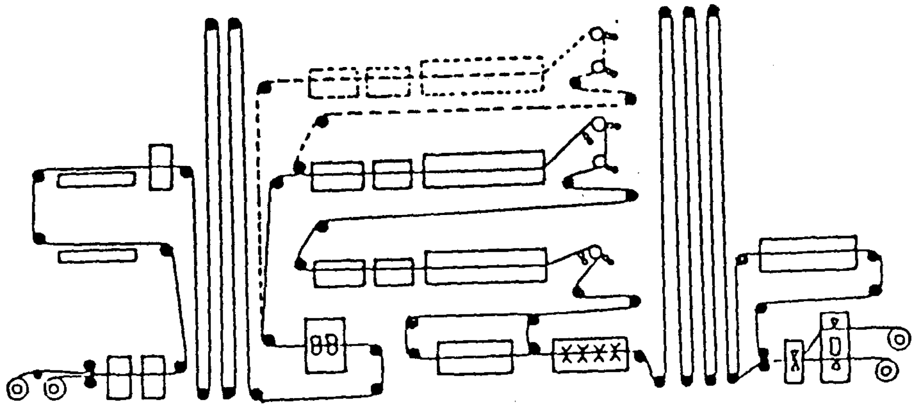
SCHEMATIC DIAGRAM ON THE ZINC POT OF NO. 3 C.G.L.

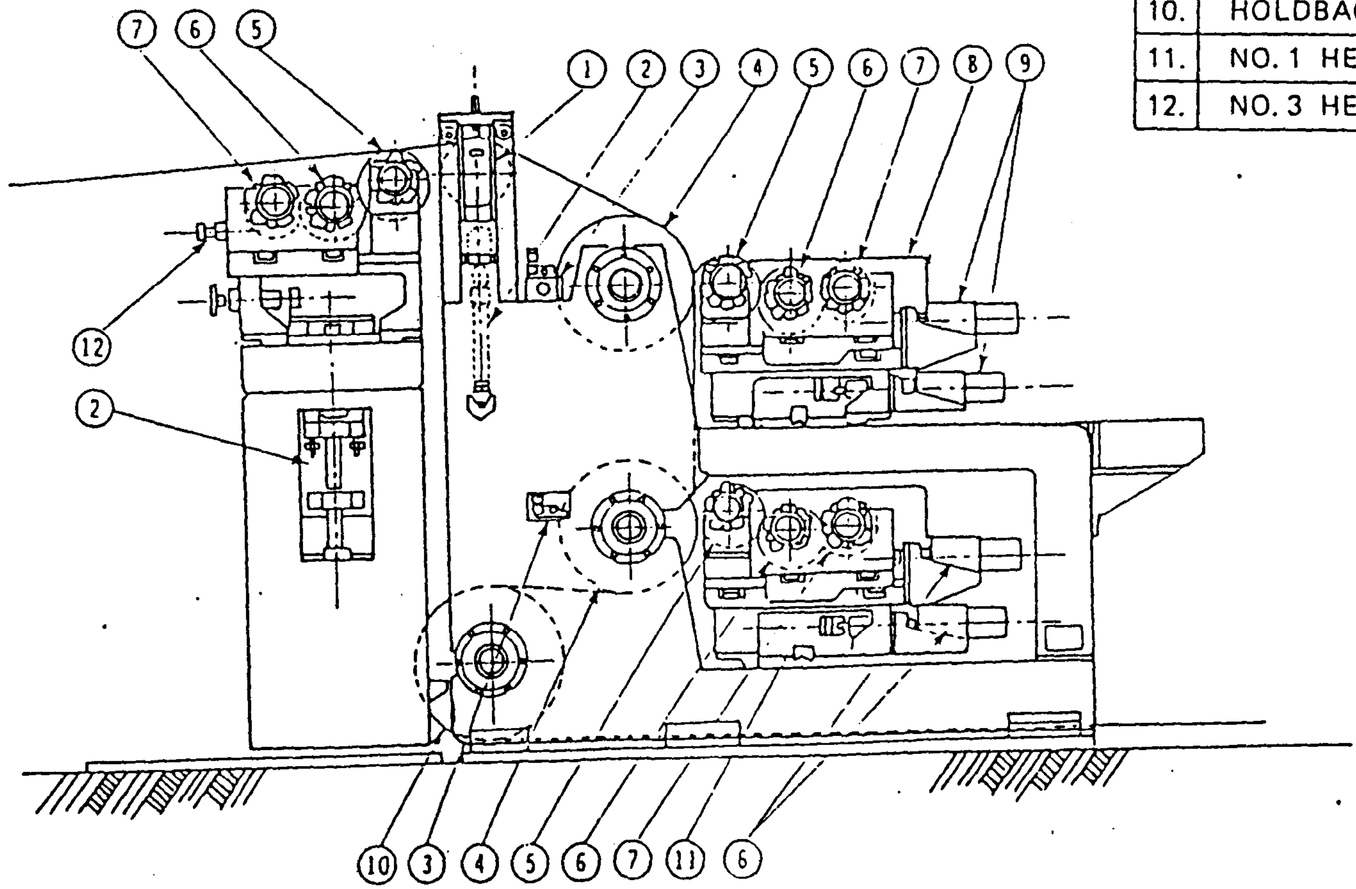
NO.	ITEM
1.	NOZZLE RIG
2.	SUPPORT ROLL RIG
3.	COATING NOZZLE
4.	SUPPORT ROLL
5.	DROSS COLLECTOR
6.	SINK ROLL RIG
7.	SINK ROLL
8.	CERAMIC POT
9.	ZINC PROVIDE EQUIPMENT
10.	SNOUT
11.	PREVENTION DEVICE FROM VIBRATION





SCHEMATIC DIAGRAM ON NO. 2 COATING MACHINE OF NO.3 C.C.L.



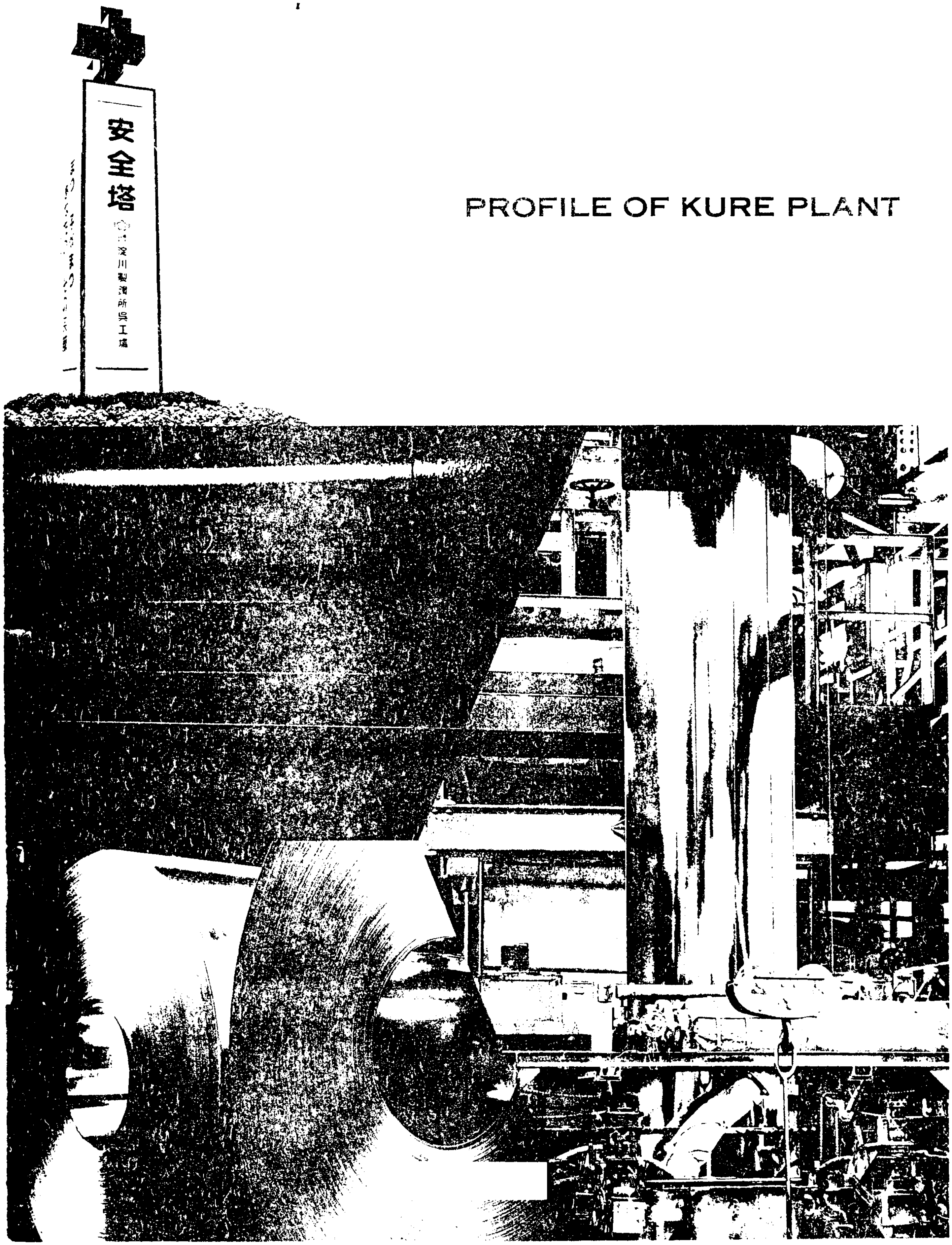


NO.	ITEM
1.	LIFT ROLL
2.	LIFT CYLINDER
3.	DOCTER ROLL
4.	BACKING ROLL
5.	APPLICATER ROLL
6.	PICK UP ROLL
7.	METALING ROLL
8.	NO. 2 HEADER
9.	STEPPING MOTOR
10.	HOLDBACK ROLL
11.	NO. 1 HEADER
12.	NO. 3 HEADER

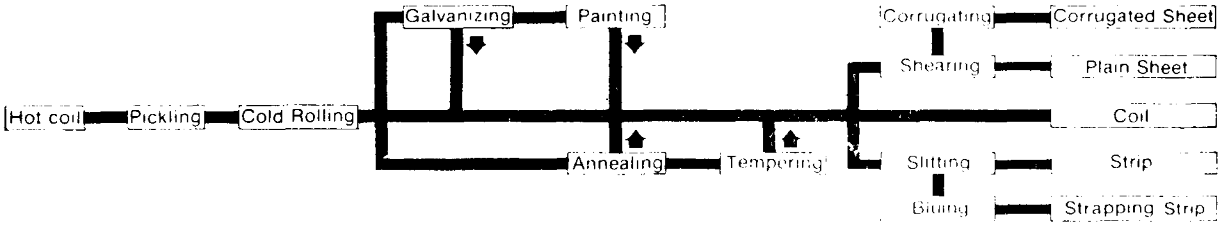
PRODUCT LIST IN CHIBA WORKS – 2

Developed year	Brand Name	Characteristics
1981	Galvanealled sheets	Alloyed steel sheets with minimum thickness 0.4 mm, which is mainly for automotive & electric appliances.
1982	Zincro metal	Coated sheets by zincrich paint for automotive usage.
1982	1-½ (One & half)	Differential galvanized sheets (A01 in top side, G60 in bottom side)
1982	One side galvanized steel sheets	Stop-off-coating (SOC) method by using special agent, for automotive usage.
1983	Resino 10-s	Sheets guaranteed for 10 years against brown rust & cracks
1984	Resino lami	Steel sheets laminated by vinyl chloride film.
1984	Resino lithin	Powder-sprayed steel sheets.
1984	Resino galfan	Steel sheets coated by Zinc-Aluminum (5%) for high corrosion resistance.
1985	Resino dull ace GF	Prepainted steel sheets with dull surface on Resino galfan, which is guaranteed for 10 years.

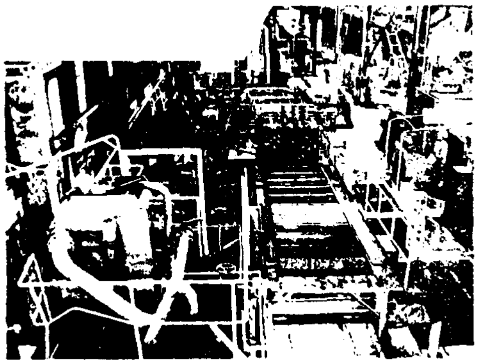
PROFILE OF KURE PLANT



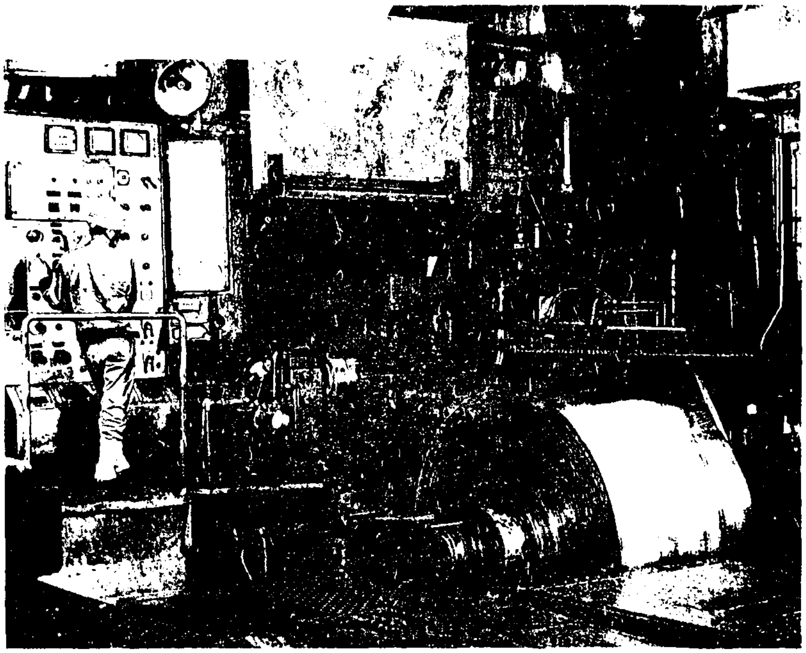
■ Production Process



Heated slab is rolled by Hot Rolling Mill to produce Hot Rolled Steel. We select raw material which best suit our customer's needs.

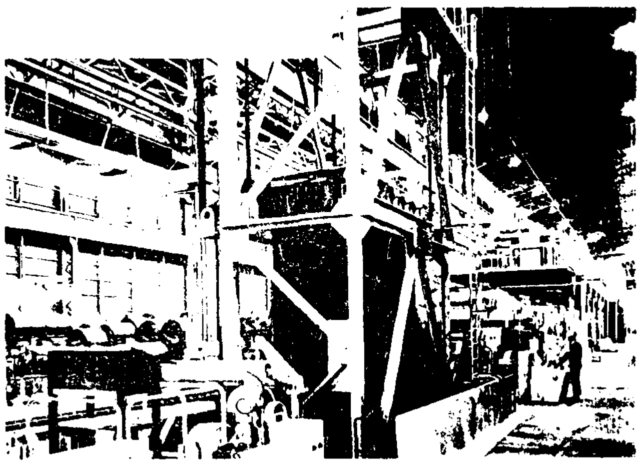


Hot Rolled Steel is processed through a scale breaker, then into a pickling zone to clean the surface.



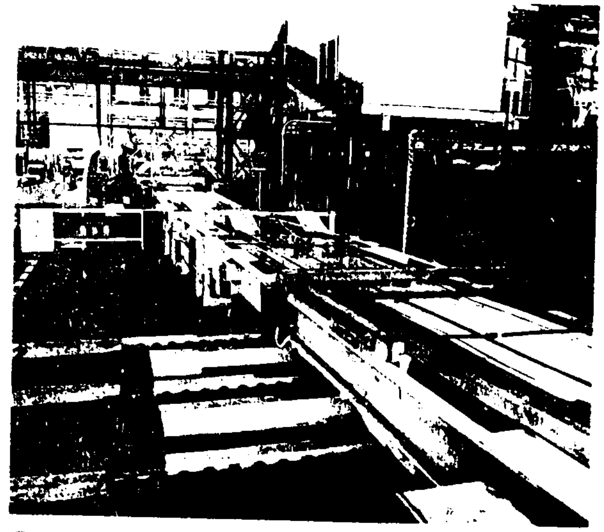
Four-High Reverse Cold Rolling Mill is used to roll the Hot Rolled Steel to designated thickness. Yodogawa is proud of its technique of rolling ultra-thin steel as thin as 0.12 mm (0.005").

Cold Rolled Steel is fed to a continuous galvanizing line with a built-in non-oxidization furnace. A small amount of aluminum is added to molten zinc to prevent steel from developing an alloy layer and to enhance the adhesion of zinc onto the steel. Galvanizing is the most popular and economical way of preventing steel from rusting.

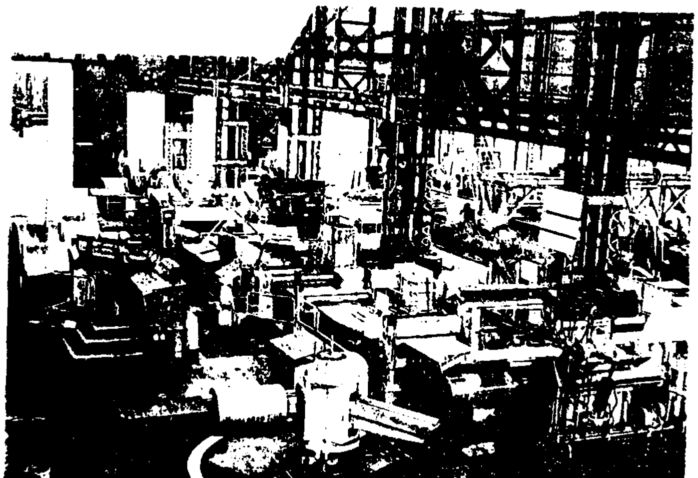


2-coat 2-bake coil coating line decorates the surface of galvanized or cold rolled steel and at the same time, enhances weather and corrosion resistant properties.

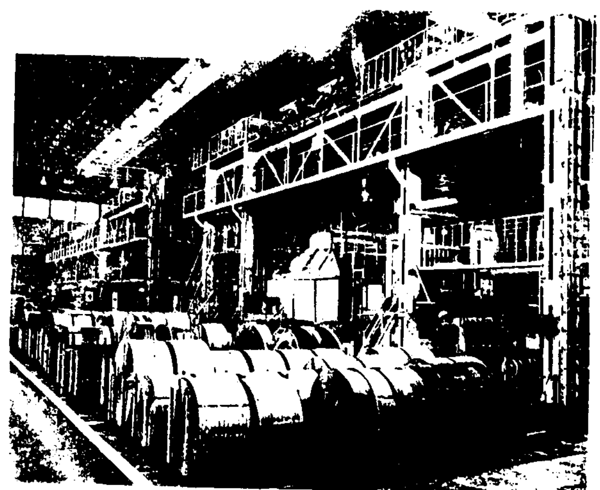
Steel hardened by Cold Rolling process is annealed to obtain the properties suitable for various applications which require good ductility



Precision shearing line cuts coil to any length with high accuracy



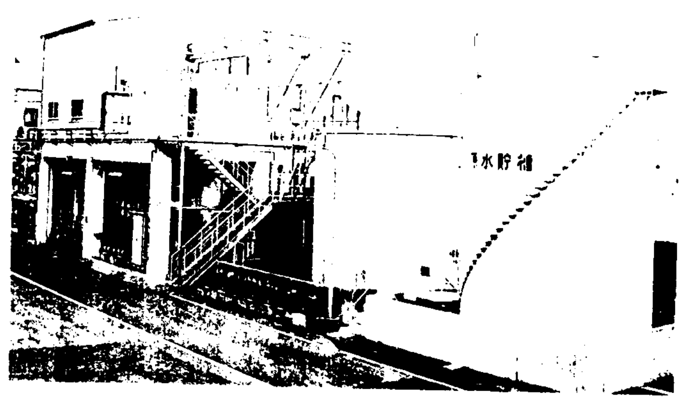
Slitting Line can slit steel coil into width as narrow as 5.5 mm



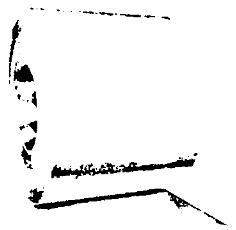
Bluing Line
Slitted strip is tempered on the Bluing Line to give the steel oxidized surface in blue color for rust prevention and good appearance.

■ Waste water treatment facilities

Waste Water coming out of Cold Rolling, Pickling, Color Coating and Bluing Line is treated chemically and disposed in much cleaner condition than stipulated in the Government Standard

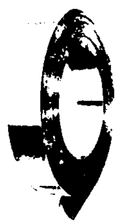


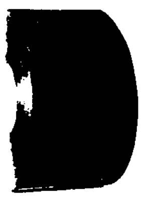
■ Products



▲Cold rolled steel sheet
▲Galvanized steel sheet

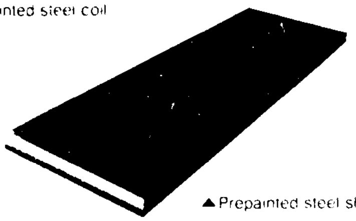
▲Cold rolled steel coil
▲Galvanized steel coil





▲Cold rolled steel strip
▲Galvanized steel strip
▲Prepainted steel strip

▲Prepainted steel coil



▲Prepainted steel sheet

Prepainted Steel Sheets:
Roof & wall panels and other building materials, electrical appliances and other household appliances, etc.

Galvanized Steel Sheets:
Roof & wall panels and other building materials and applications which require rust resistant property.

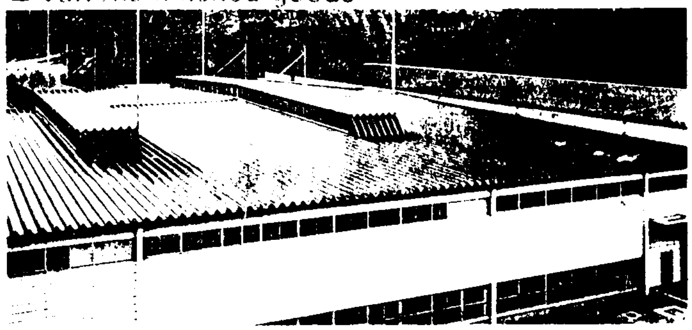
Galvanized Corrugated Sheets:
Roofing and siding panels.

Cold Rolled Sheets for Galvanizing:
Supplied for our affiliates abroad to make galvanized sheets.

Cold Rolled Steel Strips:
Machine parts, pipes, strapping and other miscellaneous applications.

Strapping Steel
Strapping and Bailing of various products.

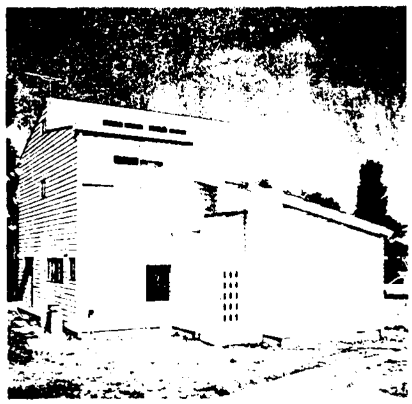
■ Various finished goods

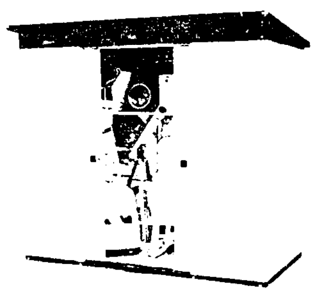


▲ Roofing [illegible]

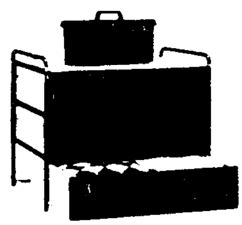
▼ Cupboard

▲ [illegible]

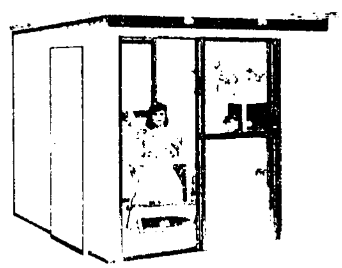




▲ Shed

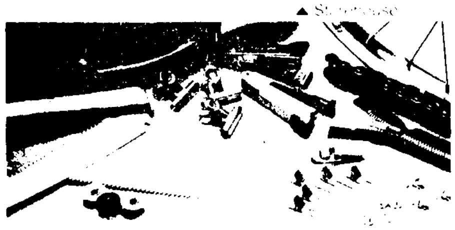


▲ Rack

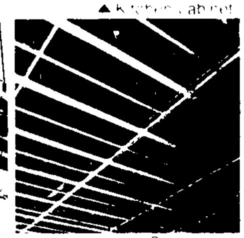


▲ Storehouse

▲ Kitchen cabinet

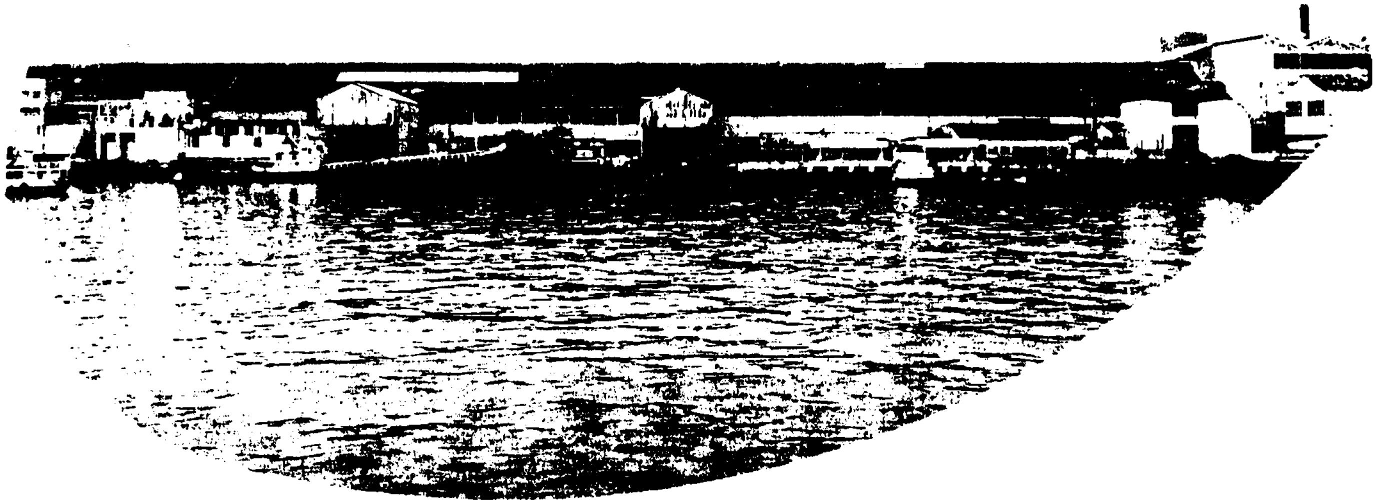


▲ [illegible]



▲ Ceiling joist

The Kure plant is one of Yodogawa Steel's four major plants, specializing in Cold Rolling, Galvanizing and Color Coating operations.

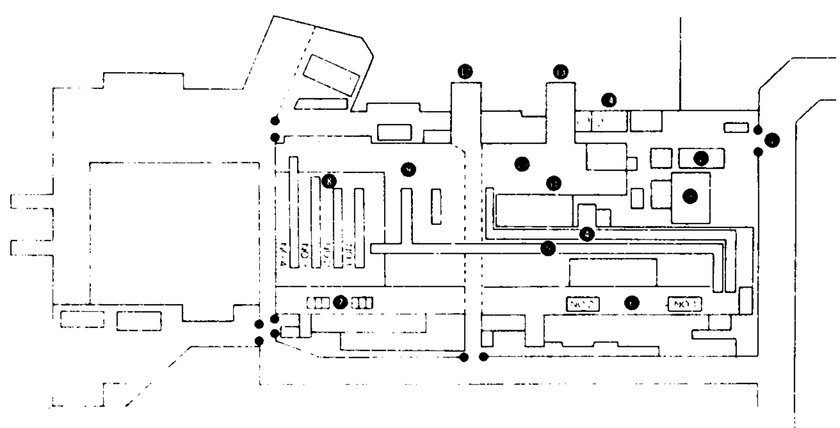


Since its foundation in 1935, Yodogawa Steel has expanded its operation into different fields and established a firm stand on each line of products, i.e., steel sheet products of various finish; rolls for steel, paper and other industries; building and home utensils; and international operations of steel-related manufacturing facilities.

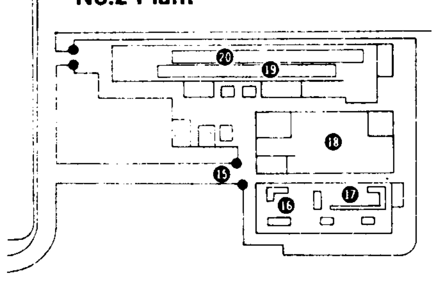
Name: Yodogawa Steel Works, Ltd., Kure Plant.
Address: 9-1, Showacho, Kure, Hiroshima, Japan
Products: Cold Rolled Steel Sheets and Strips
Galvanized Steel Sheets & Strips
Prepainted Steel Sheets & Strips
Ground Area: 76,900 m²
Building Area: 48,800 m²
Employees: 430 (as of September 1984)

Equipment	Num.	Nominal output
Pickling line	1	40,000 t/mo
Cold rolling mill	2	40,000 t/mo
Annealing furnace	2	6,000 t/mo
Galvanizing line	2	20,000 t/mo
Painting line	1	6,000 t/mo
Shearing line	4	18,000 t/mo
Slitting line	1 / 3	5,000 t/mo
Bluing line	1	2,500 t/mo

No.1 Plant

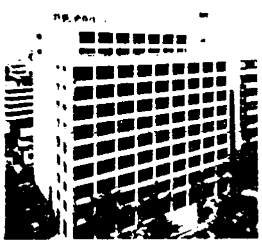


No.2 Plant

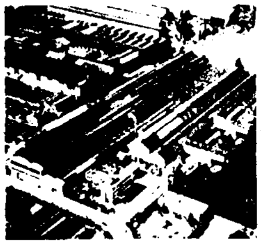


1. Main gate
2. Main office
3. Transformer station
4. Pickling line
5. Galvanizing line
6. Cold rolling mill
7. Annealing furnace
8. Shearing line
9. Products warehouse
10. Products warehouse
11. Raw materials warehouse
12. Wharf
13. Wharf
14. Waste water treatment facilities
15. Main gate
16. Sliting line
17. Bluing line
18. Products warehuse
19. Painting line
20. Galvanizing line

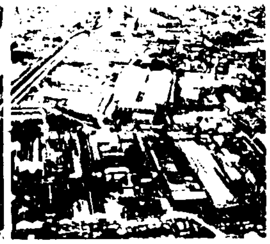
• Head office



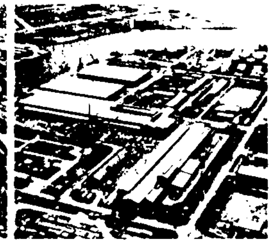
• Kure Plant



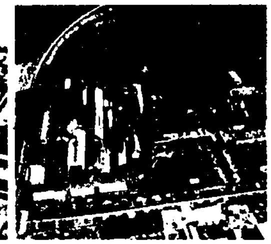
• Ichikawa Plant



• Osaka Plant



• Izumiohtsu Plant



■ Profile of Yodogawa Steel

Founded: January 30. 1935
Capital: 5.700.000.000 yen
Employees: 1850
Line of Business:

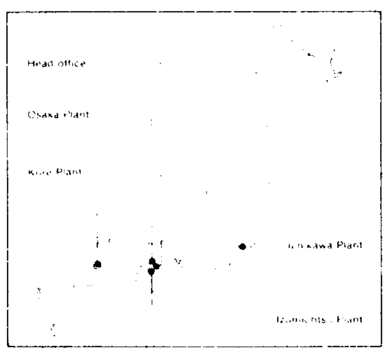
1. Manufacturing and sale of the following products
   Cold Rolled. Galvanized and Prepainted Steel Sheets
   Building Materials. Home Appliances & Utensils
   Rolls
   Billets
   Other Steel Products
2. Design & Construction
3. Real Estate

■ Offices & Plants

Head office: Osaka
Branches: Tokyo. Sapporo. Morioka. Sendai. Niigata. Takasaki. Chiba. Yokohama. Shizuoka. Toyama. Nagoya. Kyoto. Osaka. Kobe. Okayama. Fukuyama. Hiroshima. Takamatsu. Kochi. Kitakyushu. Yahata. Fukuoka. Miyazaki. Kagoshima
Plants: Kure. Ichikawa. Osaka. Izumiohtsu

■ Company History

1935	Founded as producer of steel sheets in Osaka.
1940	Started production of galvanized sheets at Osaka Plant.
1948	Installed Electric Furnace and Induction Furnace and started production of cast iron and rolls.
1950	Izumiohtsu Plant completed. Began production of carbon steel. special steel and other forged steel.
1954	Kure Plant completed. Began production of cold rolled steel sheets.
1963	Installed Continuous Galvanizing Line at Kure Plant.
1964	Installed Coil Coating Line at Osaka Plant.
1965	Entered into manufacturing building materials.
1970	Added Galvanizing Line at Kure Plant. Installed Coil Coating Line at Kure Plant.
1972	Completed Ichikawa Plant and started production of cold rolled sheets. Head Office Building completed.
1973	Installed Grating Manufacturing Facility at Izumiohtsu Plant.
1974	Installed Continuous Casting Facility at Izumiohtsu Plant.
1975	Entered into production of household utensils.
1978	Installed Continuous Galvanizing Line at Ichikawa Plant.
1981	Installed Continuous Color Coating Line at Ichikawa Plant.



YODOGAWA STEEL WORKS, LTD.
Head Office: 4-36, Minamihonmachi, Higashi-ku, Osaka, Japan 〒541
Tel. (06) 245-1111 Telex 5228611 YDKOJ
Kure Plant: 9-1, Showacho, Kure, Hiroshima, Japan 〒737
Tel. (0823) 25-1111

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