INORCHEM INTERNATIONAL LLC.

AMMONIUM FREE GALVANIZING FLUX GALVACID®HSC (HIGH SURFACE CONVERSION) FOR HOT DIP GALVANIZING (HDG)

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Galvacid® Flux HSC-PF Ammonium Free

New Technology of Flux for the Hot Dip Galvanizing (HDG)

The prevailing traditionalism in the Galvanizing processes, by continuing to use Fluxes with Ammoniacal salts, contributes to the greenhouse effect, environmental pollution and harmful effects on health, which is why Inorchem International, pioneer in this development and after several years of research, has assumed as fundamental objectives the substitution of these highly harmful compounds for health and the environment, as well as achieving multiple process benefits, potential increase in production and thus, fulfilling its objectives and mission of providing: "Eco Galvanizing Technology Today" bringing a disruptive change in the use of these harmful compounds that began to be used in the IXX century, currently still applied without any positive change towards the sustainable growth and development of this industry, until now.

In this sense, "INORCHEM INTERNATIONAL, LLC", based in the city of Miami - Florida, has developed a series of products for the Galvanizing industry, which are produced in the State of Texas, for distribution throughout Latin America and Europe, aimed at minimize the impact on the environment, by new formulations that contemplate the elimination or significant minimization of chemical compounds that are susceptible a to damage the environment and demonstrating even better performance in contrast to traditional products.

One of the most important developments of INORCHEM INTERNATIONAL LLC, is the new galvanizing flux **Galvacid® Flux HSC Ammonium Free,** which is used in continuous and discontinuous Hot Dip Galvanizing Processes (HDGP) which consist in dip the steel article in kettles contentive of molten zinc.

This new Ammonium Free Flux is aimed to eradicate totally or partially, the ammoniacal fumes emanated during the hot dip galvanizing process, continuous and discontinuous, as well as reduce the corresponding high rate of zinc waste derived from the content of ammonium chloride in the conventional fluxes, present in double and/or triple salts used in the conventional process, which gives a very reactive character associated with the formation of this waste, which generates value losses of up to 40% with respect to Zinc, which is what, as a rule, the recuperator pays for this waste.

Figure 1. (a) Specimen previously pickled and rinsed, ready for immersion in Galvacid® Flux HSC-PF Ammonium Free. (b) The same piece already fluxed. It can be seen that the surface has turned dark, typical of the "High Surface Conversion", a unique feature of this development. The experience was carried out at UNICOM/Arcelor Mital, Venezuela 2015.

Applicability of the New Technology of Flux HSC (High Surface Conversion) of high Conversion Superficial for the Galvanized in Hot “HDG”

The new flux for Hot Dip Galvanizing Galvacid® Flux HSC-PF, can be used in all continuous and discontinuous processes (flux lines) that use pre-flux, but it can NOT be implemented in “Continuous Galvanizing / Furnace Line “ ***Galvanized Continuous / Line of ovens (Furnace Line) either Annealing".***

HDG process where Hot Roll or Cold Roll coils are used. After rolling, a steel strip enters a hot dip galvanizing line (HDGL). The strip is then cleaned, preheated in an annealing furnace, and transported to a bath of molten zinc.

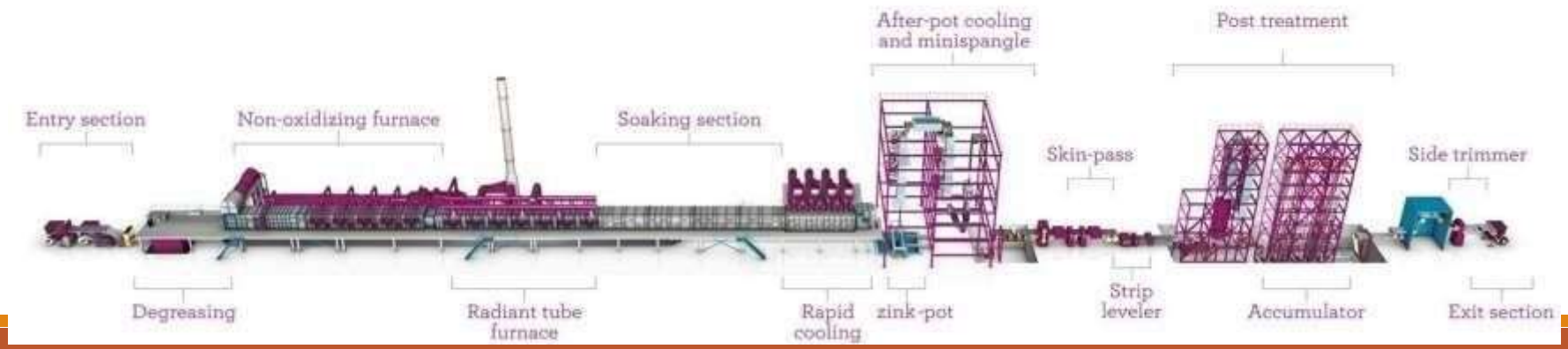

Figure 2. Continuous Galvanizing Plant, Sendzimir Method. Surface preparation is not done with chemical treatments.

HDGP (HOT DIP GALVANIZING PROCESS) VS. HTPGP (HIGH THERMAL PREPARATION GALVANIZING PROCESS)

In the traditional HDG process, surface preparation is carried out using chemical methods: it is degreased, pickled and fluxed to remove oxides and improve the adherence of zinc to the substrate, then it goes normally through a system of ***drying and/or preheating at temperatures below 150°C***. Finally, the metal is dipped in molten zinc. [7]

The ***HTPGP*** is as well a Hot Dip Galvanizing Process developed by Inorchem International LLC whose goal is to mitigate health and environmental issues found in the traditional HDGP.

This new process is similar to the HDG, but with remarkable differences in the fluxing stage, allowing the steel articles to be pre-heated at temperatures up to 200°C and 380°C, prior to dipping in molten zinc. These temperatures are closer to those on the zinc kettle (450°C-460°C), in contrast to the lower temperatures of pre-heating (*150°C)* of the HDGP, which brings unique benefits from the point of view of energy savings, environment, health and production increase. Details of these benefits will be given ahead.

The key of this new process is based in the new technology of fluxing, in which the traditional fluxes contentive of Ammonium Chloride, are replaced by a new Galvanizing Flux totally functional and free of ammonium, with High Surface Conversion characteristics, which has been developed by Inorchem International and it has been called Galvacid® Flux HSC-*PF, Ammonium Free.

The improvements of this new process, is not only seen in the fluxing stage but also in other stages such as pickling.

Other improvements which will be part of this new process, are being developed for the degreasing and passivating stages.

The next slides show the traditional HDGP and the new HTPGP proposed by Inorchem International LLC.

ENVIRONMENTAL ANALYSIS OF THE TRADITIONAL HDGP (HOT DIP GALVANIZING PROCESS)

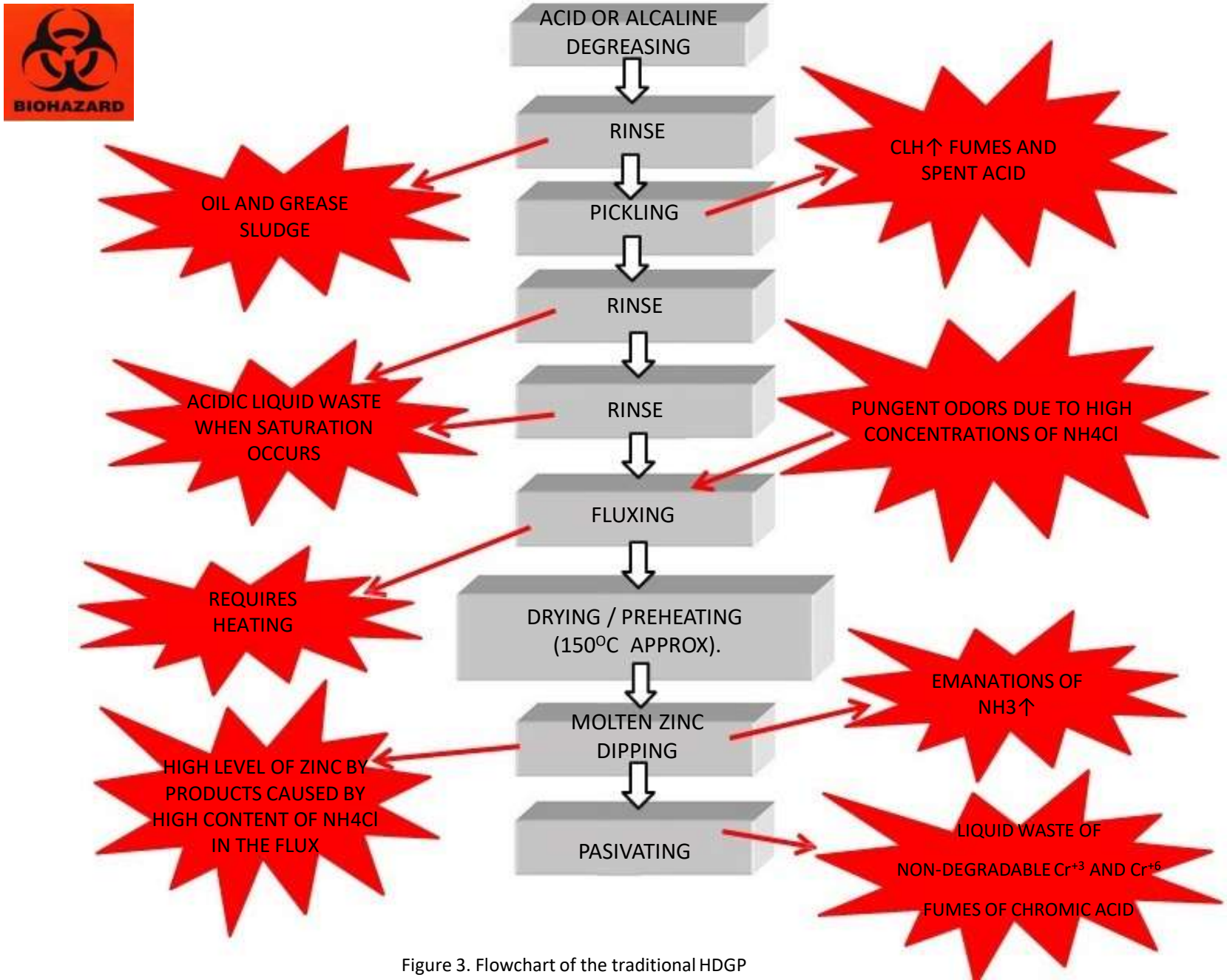

Figure 3. Flowchart of the traditional HDGP

ENVIRONMENTAL ANALYSIS OF THE HTPGP (HIGH THERMAL PREPARATION GALVANIZING PROCESS)

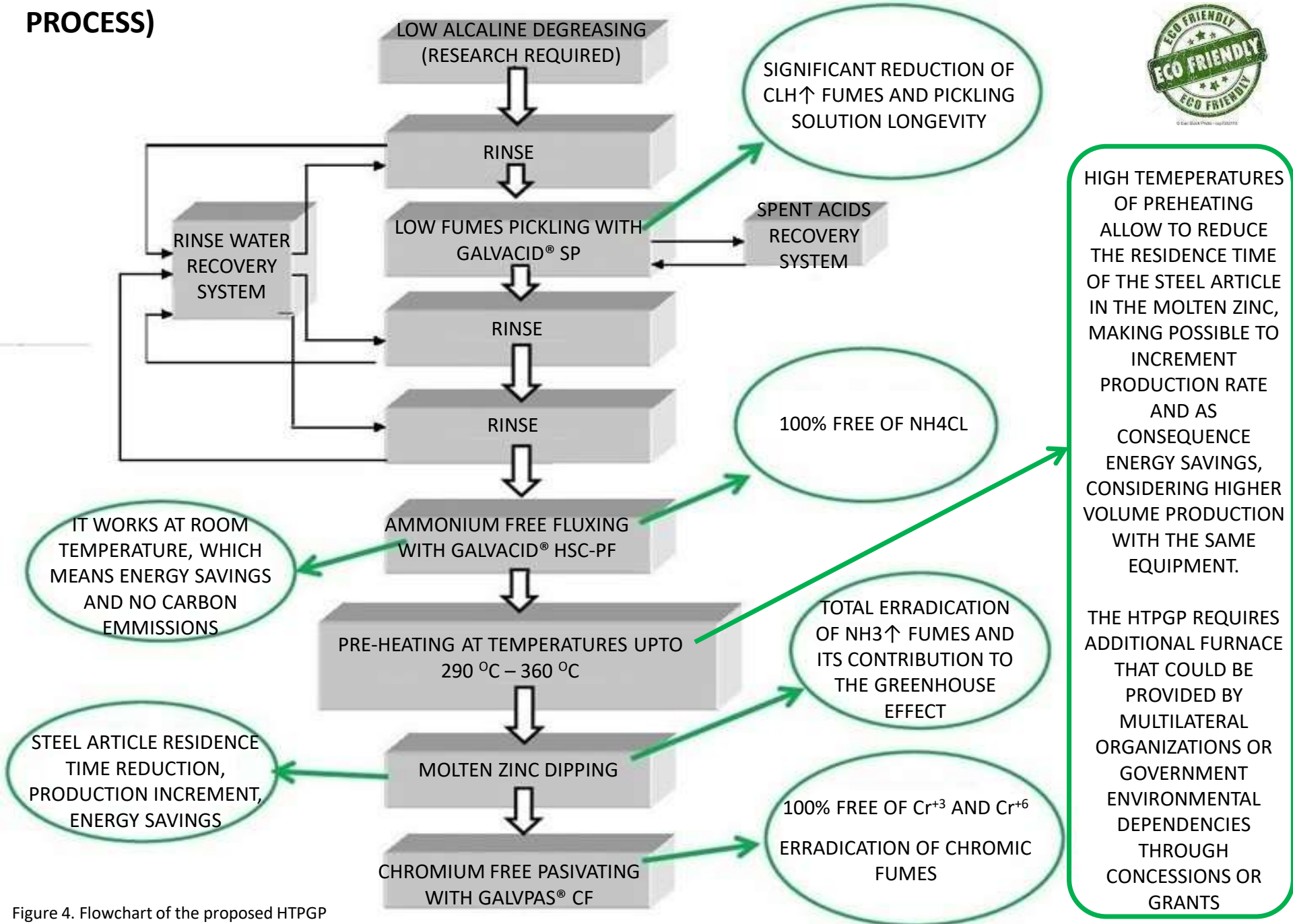

Figure 4. Flowchart of the proposed HTPGP

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Advantages of the New Technology of Galvacid® flux HSC-PF Ammonium Free, for the Hot Dip Galvanizing "HDG"

1. Elimination of ammoniacal fumes emanated as a result of the use of conventional fluxes whose content exceeds 46% ammonium chloride (double salts) with all benefits given to the working area and the environment.

The traditional fluxes, which contain Zinc Chloride, also contain significant quantities of Ammonium Chloride (NH4Cl). Its function consists to remove micro oxides from the steel surface, allowing a good impregnation with the molten Zinc, achieving a good adhesion over the surface of the steel article.

During galvanizing, the steel articles fluxed with conventional mordants, are dipped in the molten zinc to 440º - 460ºC, in which the Ammonium Chloride decomposes according a the following reactions:

$$NH_4Cl \rightarrow NH_3\uparrow + HCl \quad (1)$$

$$NH_4Cl + ZnCl_2 \rightarrow ZnCl_2.NH_3 + HCl \quad (2)$$

Other reactions that occur in the medium are:

$$FeO + 2HCl \rightarrow FeCl_2 + H_2O \quad (3)$$

$$FeO + 2NH_4Cl \rightarrow FeCl_2 + 2\,NH_3\uparrow + H_2O \quad (4)$$

Figure 5. On the left, three articles of steel fluxed with conventional Flux of zinc and ammonium chloride salts, and on the right, articles of steel fluxed with Galvacid® Flux HSC-PF Ammonium Free. It can be seen that, on the left side, the pieces emanate toxic fumes of ammonia and water vapor, while on the right side, the pieces fluxed with free ammonium flux present a significant reduction of emanations, in fact, there are no ammonia fumes. since this new flux is free of ammonium salts. Somanin, Venezuela, 2015.

Ammonia ($NH_3\uparrow$) is irritating and the liquid and gas produce burns in the skin, eyes, mouth and lungs, also reacts with the oxygen on the atmosphere to form N2O, a gas of greenhouse effect.

With the implementation of Galvacid® Flux HSC-PF Ammonium-Free Galvanizing Flux, ammonia emissions (NH3 ↑) are completely eradicated.

2. Thermostability in ranges up to in 360°C and 380°C - Certificate by Lab. of Materials “Engineering Systems Inc. - USA" -.

This unique property of the Ammonium Free Galvacid Flux® HSC, allows to preheat the article at temperatures up to ranges of 360°C -380°C, much higher of those temperatures in which the traditional flux degrades, bringing rejections in the galvanizing.

Based on this property, Inorchem International has defined a new hot-dip galvanizing process called HTPGP (High Thermal Preparation Galvanizing Process), in which it is possible ***to reduce the residence time of the steel article in the molten zinc kettle up to 80%, as consequence, production increase and reduction of energy consumption applied to the molten zinc kettle near to 80%.***

3. Elimination of Greenhouse Gases (GHG) emissions, such as N2O and CO2

The industrial sector ranks second in total global GHG emissions (19.4%), preceded only by the energy sector (25.9%). The galvanizing industry is found in the industrial sector, which, due to the use of traditional fluxes with high contents of ammonium chloride (NH3Cl), generates ammoniacal fumes NH3↑, which in turn react with oxygen in air, to form N2O, one of the main gases causing global warming (see reactions (1) and (4) of the previous slide), with a potential of heating 298 times more than that of the CO2, in a period of 100 years.

$$2\ NH_3\ (g) + 2\ O_2\ (g) \rightarrow 3\ H_2O\ (l) + N_2O\ (g) \quad (5)$$

In contrast, the new flux HSC, does not have Chloride of Ammonium, as consequence, generation of fumes of ammonia is not possible, avoiding the formation of **N2O** in the atmosphere.

It is important highlight also that, as consequence of the thermostability, significant energy savings are achieved, contributing also to the removal of GHGs, in this case, the CO2 derivate of those savings, according to the next balance of energy:

$E_{(HTPGP)\ savings} = E_{(ZINC\ KETTLE)\ savings} + E_{(RESIDENCE\ TIME)\ savings} - E_{(PRE\text{-}HEATING\ EQUIP)}$

Certified by ESI up to 80% versus the process HDG regular

It refers to the relative energy savings achieved due to increase of production as consequence of the reduction of the residence time of the steel article dipped in the molten zinc kettle

Energy invested in preheating the steel article by efficient equipment, through induction or forced convection.

4. Significant reduction of zinc byproducts

Figure 6. On the left, ashes of Zinc, on the right "dross". Examples of waste of zinc during the process of galvanizing. The use of this new technology has proven that these byproducts can be significantly reduced, which implies considerable saving of zinc for the galvanizer.

5. High Surface Conversion Capacity:

This property is totally different from conventional galvanizing fluxes, fully functional to process the entire range of steel elements (structures, pipes, wires, coils, among others).

Figure 7. Continuous wire process. Finished galvanized wire, with 100% ammonium removal. A galvanized with good brightness and without rejections is observed.
Wires Yaracuy – Venezuela. February 2017

Figure 8. (a) Electrical steel article with complex geometry, fluxed with the new Galvacid® Flux HSC-PF Ammonium Free. It can be seen that the surface has turned black, typical of the "High Surface Conversion", unique characteristic of this new development. (b) The same part already galvanized, showing perfect galvanization, gloss, free of bare dots zinc coating. Discontinuous Process (Batch) Immermek, Mexico 2019.

Figure 9. Structures fluxed with Galvacid® flux HSC-PF ammonium free followed by subsequent galvanizing. SOMANIN, Venezuela, 2016.

Figure 10. Pipeline fluxed with Galvacid® flux HSC-PF ammonium free of ammonium and subsequently galvanized. TUBAC, Guatemala, 2018.

6. Control and reduction of zinc coating.

The reduction becomes feasible, due to the possibility of shorter immersion times, when working with **Galvacid® Flux HSC Ammonium Free,** because it promotes a faster Galvanization due to its unique reaction mechanism, as long as that reduction is permissible for the user, because certain parts must comply Standards, when they use conventional Fluxes of double or triple salts with Zinc Chloride and Ammonium Chloride.

7. Reduction of rejections in the Galvanizing:

This advantage is exploited to its fullest when the surface preparation of the steel is optimal, as the surface conversion is a high speed chemical reaction that occurs in the whole surface of the steel article, regardless of geometrical complexity of the part.

Figure 11. (a) Piece of tower of electricity with complex geometry, fluxed with the new Galvacid® flux HSC-PF Free of Ammonium. It can be observed that the surface is turned black, typical of the "High Surface Conversion", unique characteristic of this new development. (b) The same part already galvanized, with a parfect galvanization.

8. Elimination of TOP FLUX together with all its negative impact in terms of working environment and environmental pollution.

9. Possibility to keep the fluxed steel articles submitted two hours to the environment before dipping in the molten zinc:

This is possible to do without observing rejections once the article is galvanized. There are several advantages that this property could bring, at the process level, for example, It is not necessary to rework rework the steel article because the HSC remains stable during this time, due to the flux film does not react with the oxigen of the air as ussually occurs with ammoniacal fluxes.

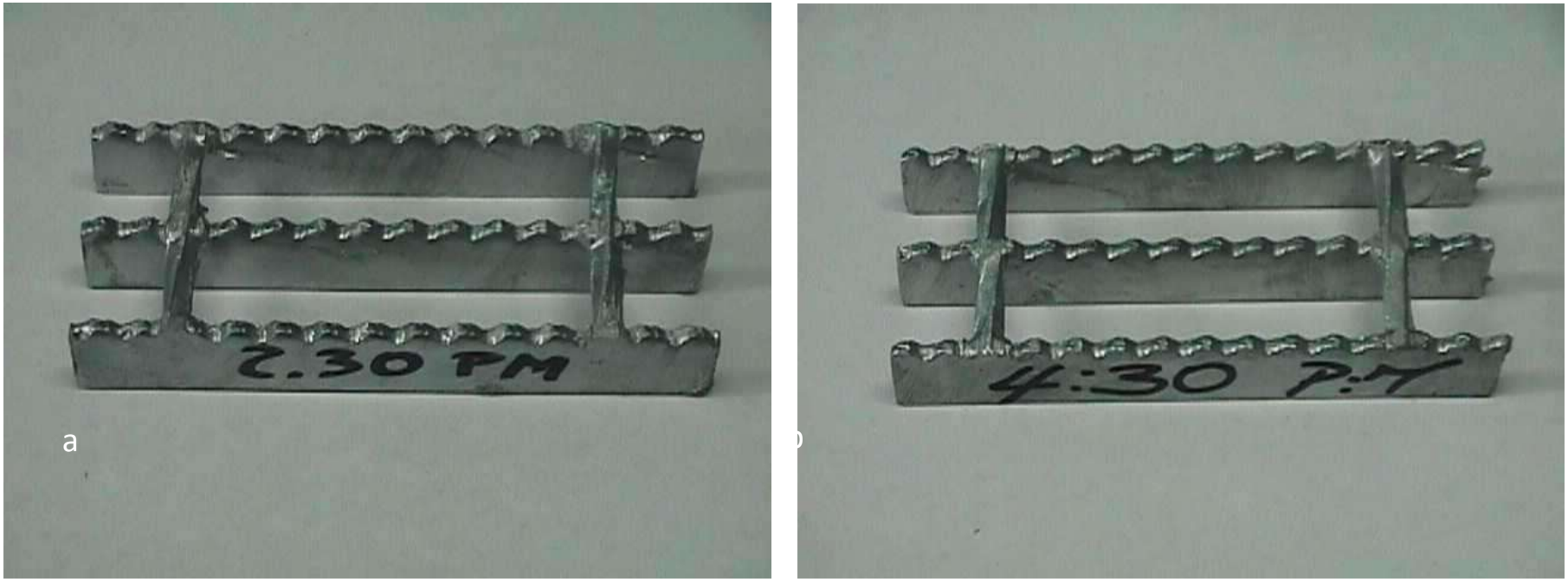

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Figure 12. (a) Part of “grating” fluxed with Galvacid® flux HSC-PF Free of Ammonium and subsequently submitted to the environment by two hours before Galvanizing. Rejections not observed in the final galvanization. (b) Piece of "Grating" fluxed with Galvacid® Flux HSC-PF Ammonium Free and subsequently exposed to the environment for 4 hours before its galvanizing. Rejections not observed in the final galvanization.

10. Liquid Product:

Easier handling in contrast to solid products, also implies easier dosing, concentration and operational specific gravity control.

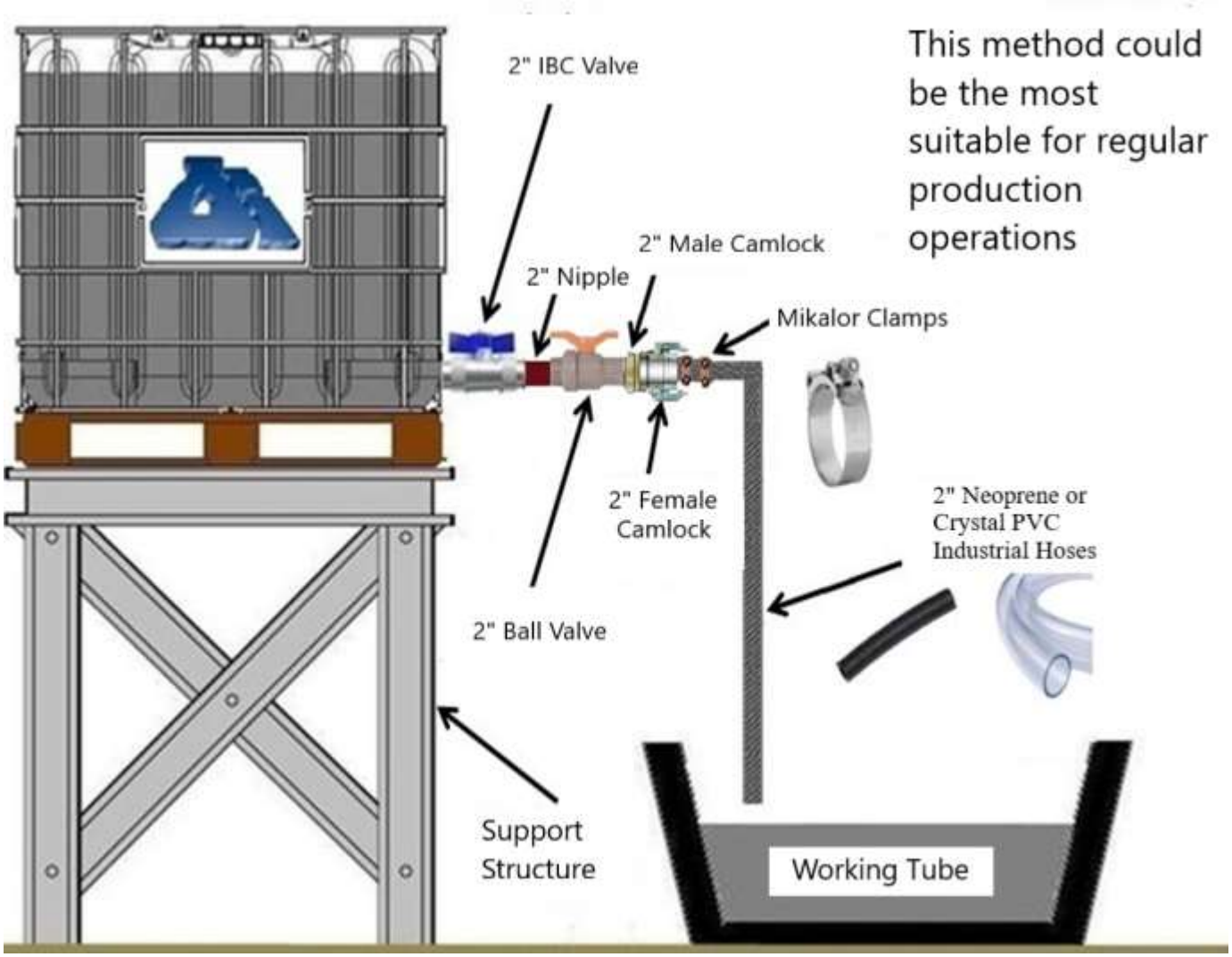

Figure 13. Galvacid® Flux HSC-PF, being a liquid product, is usually distributed in 275-gallon and 300-gallon IBCs. Note the ease of dosage and maintenance of the gravity specific of bath of flux, a through of a valve of feeding. I know avoid processes of dosage Y dissolution complicated of you go out, What in the fluxes conventional.

11. Easy preparation of the working solution:

The working solution preparation ratios are very close to 30% v/v Flux HSC and 70% v/v water, which is almost the same value as the preparation of double and triple salt fluxes (30% w/w solids and 70% w/w water). Nominally, the concentrations or "set point" of working solution in the process with **Galvacid® flux HSC Free of Ammonium,** usually is of minor order than those with the conventional, fluxes, due to its unique mechanism of superficial reaction.

Table # 1. Preparation of the working solution of Galvacid® Flux HSC-PF Free of Ammonium

GALVACID® FLUX HSC (% V/V)	Density		WATER (% V/V)
	(°Be)	(Kg/L)	
100.00	63.08	1.77	0.00
86.58	58.00	1.67	13.42
79.37	55.00	1.61	20.63
68.35	50.00	1.53	31.65
58.44	45.00	1.45	41.56
49.47	40.00	1.38	50.53
41.32	35.00	1.32	58.68
33.88	30.00	1.26	66.12
31.08	28.00	1.24	68.92
27.06	25.00	1.21	72.94
24.48	23.00	1.19	75.52
20.78	20.00	1.16	79.22
18.41	18.00	1.14	81.59
16.11	16.00	1.12	83.89
14.99	15.00	1.12	85.01
12.79	13.00	1.10	87.21
10.66	11.00	1.08	89.34
9.62	10.00	1.07	90.38
4.64	5.00	1.04	95.36
3.68	4.00	1.03	96.32

12. Operability at room temperature :

Galvacid® Flux HSC Ammonium Free works at room temperature (25ºC), which means there is no need for complicated equipment like heat exchangers and its correspondent source of heating (inductors, direct flames, etc.), to keep the temperature between 70 ºC and 80 ºC, which represents an appreciable energy consumption and a contribution to the reduction of the Greenhouse Effect. Alsoit is possible to heat the flux to increase the temperature of the pieces before the process of drying, either pre-heating can be done without any problem.

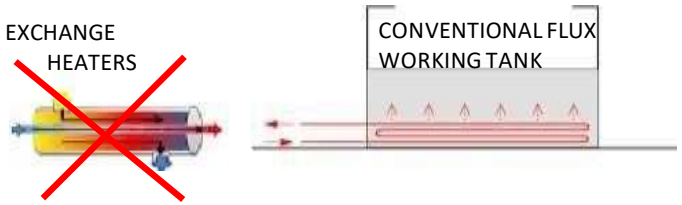

Figure 14. Illustrative diagram of the heating of a conventional Flux tank to temperatures between 70ºC and 80ºC, which implies energy costs and therefore higher costs. With the implementation of Galvacid® Flux HSC-PF Ammonium Free, heating of the working solution is not required, since it works at room temperature.

13. Better Yields:

In general, Galvacid® Flux HSC Ammonium Free has demonstrated better yields in certain types of processes however, each plant has its own operational features and assessment techniques; for example, for the evaluation of flux film dragging towards the next stage.

This flux is a solution with a lower surface tension than tradition ammonia fluxes, so a lower relative consumption is projected.

NOTE: This over yield is particular to a Wet Flux process.

	Average 2017	Nov-Dec 2018	Jan-Feb 2019
FLUX GL/TON	0.57	0.22	0.26

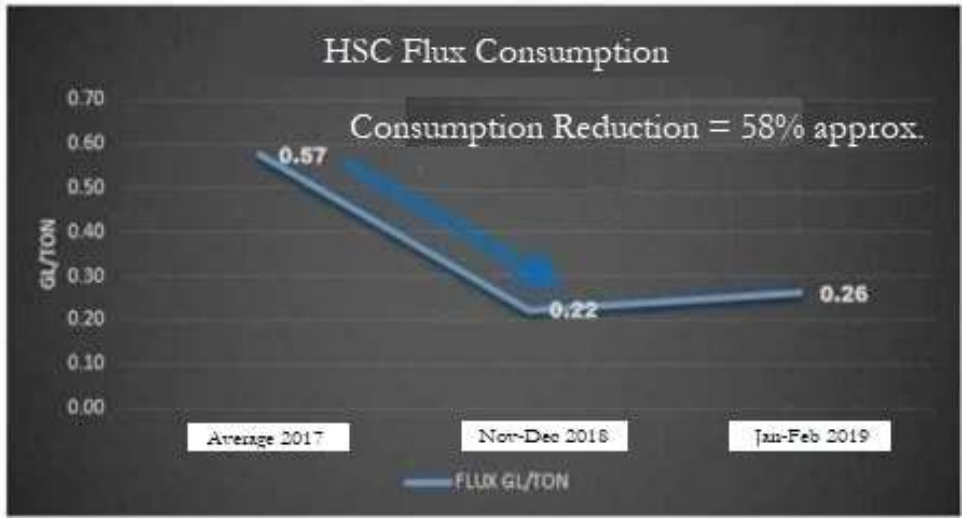

Figure 15. Comparison of the consumption of conventional flux versus Galvacid Flux SCH-PF Ammonium Free in a continuous steel coil plant (Wet-Flux Line). A significant reduction in flux consumption (Gallons of Flux/MT of steel processed) is observed when switching from conventional flux to ammonium free flux. Alutech, Honduras 2019.

14. Better appearance and excellent adherence of coating zinc:

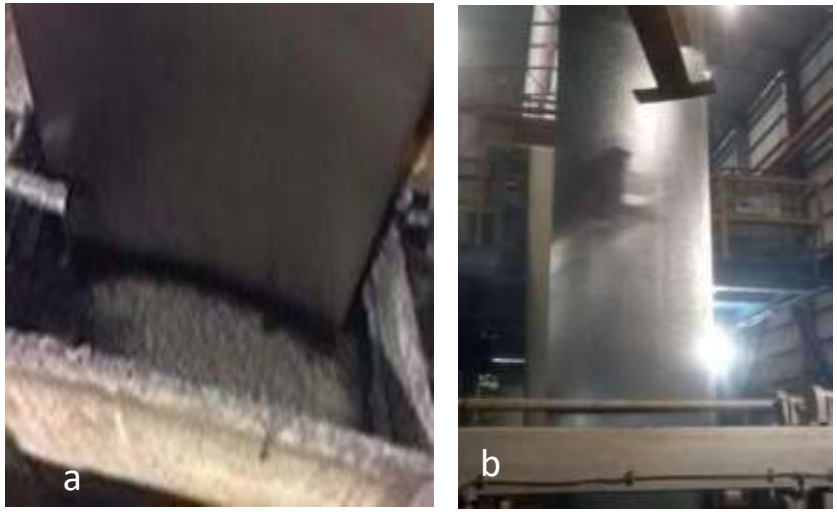

Figure 16. (a) Flux bath contentive of Galvacid® Flux HSC Ammonium Free. (b) Steel sheet already galvanized. It is observed a good galvanizing and without rejections. Process of Continuous Steel Coil galvanizing. Alutech, Honduran 2019.

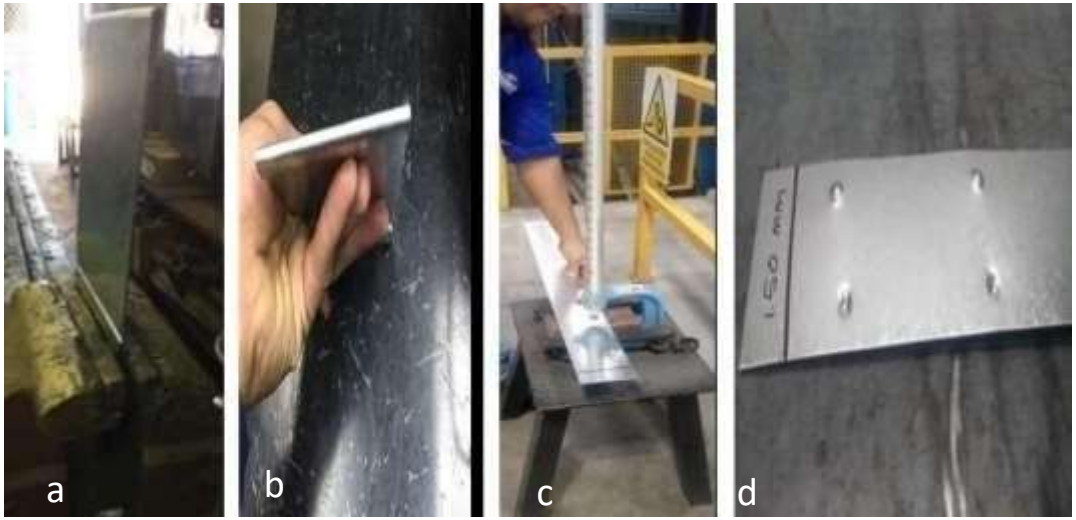

Figure 17. (a) Test of adherence. (b) Bending Test. (c) Impact Test, (d) Proof of Impact. All tests tests showed good adherence of zinc coating on the steel sheet. Continuous Galvanizing Process. Aalutech, Honduras 2019.

15. Recyclable Flux:

Recovery and recycling by cleaning the Flux (removal of iron) under the same methodology as the conventional procedures, with pH between 3.8 Y 4.2, with results close to 0.05% of iron.

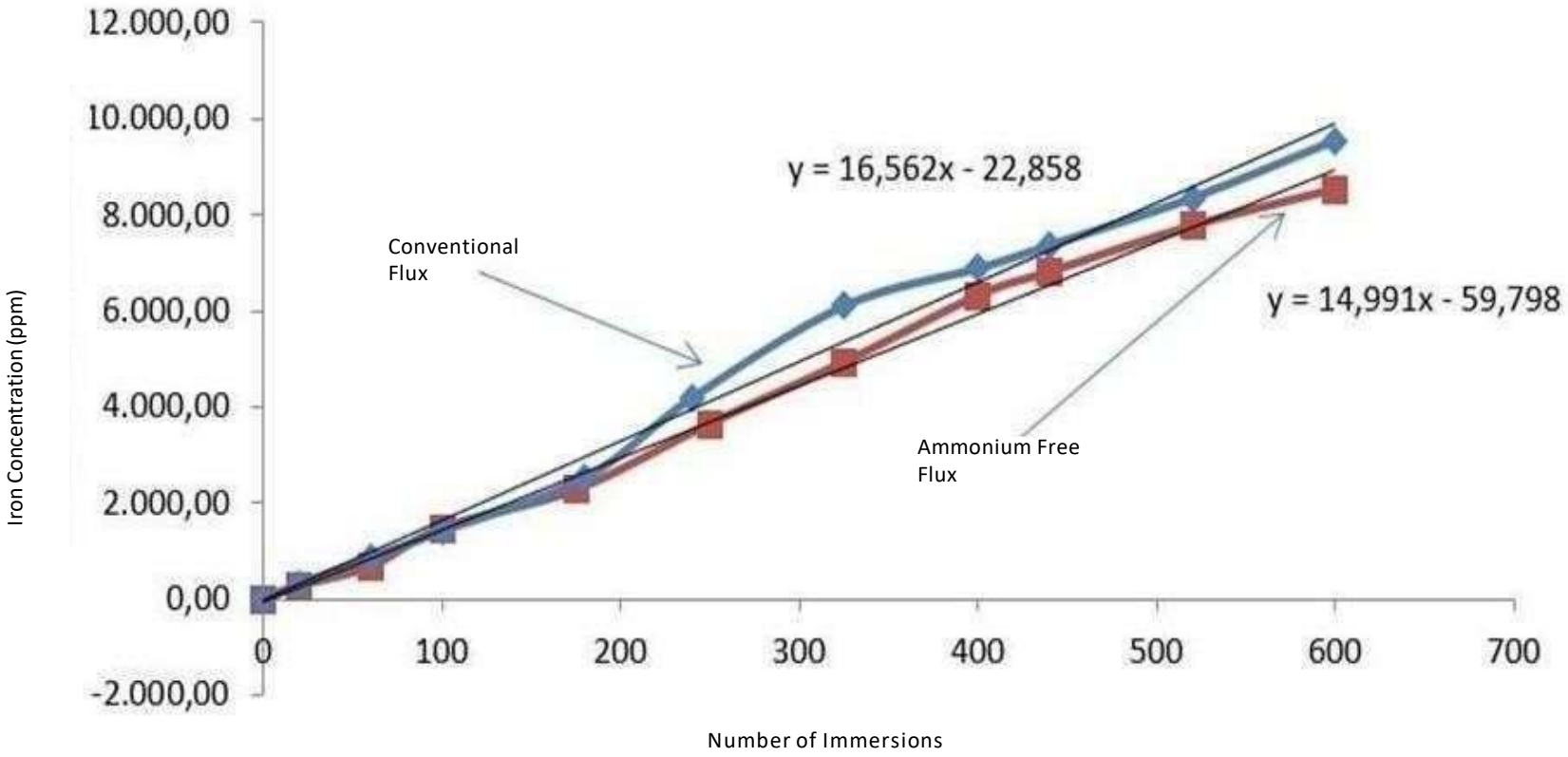

Figure 18. Comparative example of accelerated iron gradient curve (nominally the usual radius is 2 TM / 5 m3). Chart radius: 4 TM steel / 5 m3 of working solution. The Galvacid® Flux HSC-PF formulation has been developed for optimization of recovery/recycle. It can be seen that the gradient of iron in Galvacid Flux HSC-PF is equal to or less than the gradient of conventional Flux with ammonia. Note that if the Radius is smaller, the iron gradient per immersion will be lower.

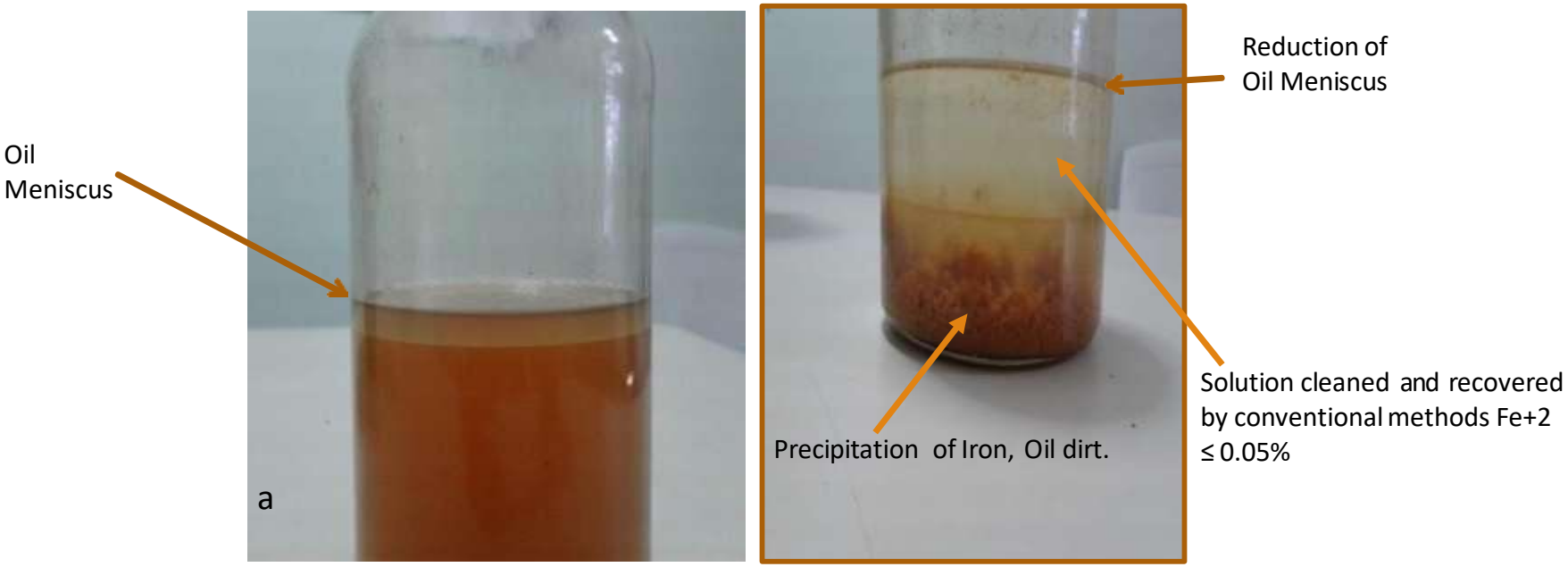

Figure 19. (a) Example of oil-induced contamination in the Ammonium Free HSC Flux working solution. (b) Ammonia-free flux solution after recycling/recovery process.

Special formulations of Galvacid® HSC are allowed and can be used depending on the migration of dirt to the flux tank, with a partial "Self-cleaning" effect during operating activities, favoring the phenomena of coagulation, sedimentation and precipitation of both Fe +3, as well as possible traces of oil and other organic contaminants, from previous stages of surface preparation, due to drag downstream of the process, which can reach the flux tank, eventually impregnating the pieces and deteriorating the appearance of the galvanized.

The result is faster precipitation in the recovery/recycling process, which will represent an important advantage, as the flux tank is available in less time, which translates into increased of production.

Example of identification of 3 phases in the recovery of a conventional Flux recycled in Processes with poor surface preparation, which shows dragging of oils and dirt towards the Flux Tank

Figure 20. Example of identification of 3 phases in the recovery of a conventional Flux recycled in processes with poor surface preparation, which shows dragging of oils and dirt towards the Flux Tank

PHASE I : supernatant Fe++ ferrous solution

PHASE II : Iron precipitation (Fe+++)

Phase III: Glycerol and soaps (sodium) derived from the saponification with NaOH of vegetable oils, due to deficiencies in degreasing (upstream in the process). This phase precipitates as the heaviest, due to its molecular composition with aliphatic chains ρ= 1.30 > 1.15

CONCLUSIONS

The adoption of the new Ammonium Free Galvacid Flux® HSC (High Surface Conversion) includes a series of advantages, summarized below:

1) Elimination of ammoniacal fumes generated as a result of the use of conventional fluxes, whose content exceeds 46% ammonium chloride (double salts) with all the benefits granted to the work area and the environment.
2) Thermostability in ranges between 360°C and 380°C, which results in the reduction of the residence time of the steel article in the molten zinc up to 80%, which brings advantages in the increase of production and reduction of the energy consumption supplied to the molten zinc kettle close to 80% in galvanizing.
3) Elimination of the generation of Greenhouse Gases (GHG), such as N2O and CO2.
4) Significant reduction of zinc by-products/waste (slag, ashes, etc.).
5) High surface conversion capacity, totally different feature in contrast to conventional galvanizing fluxes, fully functional to process the whole range of steel elements (structures, pipes, wires, coils, among others).
6) Control and reduction of zinc coating.
7) Elimination and/or reduction of rejections in Galvanizing.
8) Elimination of TOP-FLUX with all its negative consequences in terms of work environment and environmental pollution.
9) Possibility of leaving the treated parts exposed to the atmosphere for 2 hours before dipping them in the zinc kettle, highly advantageous to avoid reworks.
10) Liquid product, which means easier handling in contrast to solid products, also implies easier dosing, concentration and operational specific gravity control.
11) Easy preparation of the working solution.
12) Operation at room temperature.
13) Better Yields
14) Recyclable Flux

Final comments:

The prevailing traditionalism in the Galvanizing processes, by continuing to use Fluxes with Ammoniacal salts, contributes to the greenhouse effect, environmental pollution and harmful effects on health, which is why Inorchem International, pioneer in this development and after several years of research, has assumed as fundamental objectives the substitution of these highly harmful compounds for health and the environment, as well as achieving multiple process benefits, potential increase in production and thus, fulfilling its objectives and mission of providing: "Eco Galvanizing Technology Today" bringing a disruptive change in the use of these harmful compounds that were born in the IXX century, currently still used without any positive change towards the sustainable growth and development of this industry, until now.

END


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GO
GREEN


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