



Armohib© CI-28 & Armohib CI-31

Products for corrosion inhibition

ARMOHIB® CORROSION INHIBITORS

APPLICATIONS

Armohib aliphatic nitrogen inhibitors retard the corrosive effect of acids on metals during pickling, process equipment cleaning and oil well acidizing operations. *Armohib* comes in two versions for use with specific acids:

PRODUCT	ACID APPLICATIONS
Armohib CI-28	Hydrochloric Hydrochloric-Hydrofluoric acid mixtures
Armohib CI-31	Sulfuric Sulfamic Citric Phosphoric

PHYSICAL PROPERTIES

Typical Data	Armohib CI-28	Armohib CI-31
Specific Gravity @ 25°C	0.925	1.042
Density Pounds/Gallon	7.69	8.66
Appearance @ 25°C	Amber Liquid	Amber Liquid
Pour Point °F	52	24
Flash Point °F	90	340
Cloud Point °F	n/a	28

Product Attributes

- Easy to Use
- Liquid Form
- Soluble in acid
- Non-staining
- Does not precipitate when standing

Advantages

Low-cost, dependable protection over a wide range of temperatures
Economical and effective: Only a small quantity of *Armohib* mixed with the acids will deliver the desired cleaning effect while retarding acid attack on metals.

Corrosion performance-tested:

- 0.25% *Armohib CI-28* in 15% hydrochloric acid at 200°F must show less than 0.022 lb/ft²/day corrosion of mild steel.
- 0.06% *Armohib CI-31* in 15% sulfuric acid at 200°F must show less than 0.027 lb/ft²/day corrosion of mild steel.

APPLICATIONS

Following is a discussion on the three major application areas for the *Armohib products*:

- **ACID PICKLING**
- **PLANT CLEANING**
- **OILWELL ACIDIZING**

ACID PICKLING

Pickling is the removal of oxide scales formed during metal working operations by mineral acids. Hydrochloric, phosphoric and sulfuric acids are commonly used. These scales must be removed without undue acid attack on the base metal surface.

An inhibitor is therefore used to protect the cleaned surface, reduce acid wastage and metal loss and prevent pitting and discoloration of the metal. Inhibitors protect weld areas and impede "burning" of the metal, even during a temporary shutdown of pickling operations. These inhibitors form a foam blanket preventing heat loss and acid spray.

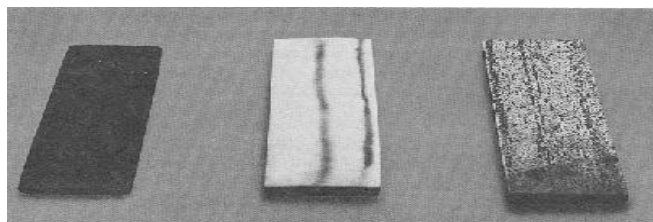
Armohib CI-28 uses: Hydrochloric acid is used for pickling very high carbon and alloy steels and for wire pickling. Hydrochloric and hydrofluoric acid blends are used to clean ferritic, martensitic and austenitic steels. Iron oxide scale is soluble in hydrochloric acid, and therefore there is no acid attack on the metal surface.

Hydrogen embrittlement is a major problem during the pickling of mild steel wire. The addition of *Armohib CI-28* to the hydrochloric acid eliminates or reduces embrittlement. This embrittlement occurs when atomic hydrogen produced by the introduction of the acids, diffuses into the lattices of the metal and strains it. This results in brittleness at the molecular level, with no advanced indications such as visible pitting.

The use of *Armohib CI-28* as an inhibitor, in hydrochloric acid pickling of steel, has no adverse effect on the quality of the metal in subsequent hot dip galvanizing. Tests conducted at an independent laboratory show that the use of *Armohib CI-28* does not have any noticeable influence on the structure of the zinc, or the thickness of the zinc layer.

Armorhib CI-31 uses: Phosphoric acid is used in the surface preparation of structural steel to remove mill scale, rust and contaminants, prior to protective surface coating. Phosphoric acid is of particular value in pickling operations where the scale film is thin, or if the film is a hydrate oxide of iron.

Sulfuric acid is used extensively in metal cleaning because of its low cost. In the absence of inhibitor, up to 80% of the acid may be wasted in dissolving metal under the scale.



Sulfuric acid pickling of mild steel. Right hand coupon prior to pickling, center coupon acid inhibited with *Armorhib CI-31*, left hand coupon no inhibitor used.

Steels that are heated *above* 575°C produce a scale that consists of three layers: *magnetite, ferric oxide, and wurstite*. This complicates the pickling process because the sulfuric acid solution and the liberated hydrogen gas, produced as a by-product of the interaction, penetrate the cracks in these layers. The use of *Armorhib CI-31* as an inhibitor regulates these complex reactions and minimizes the amount of surface material that is dissolved.

Scale produced on steels heated at temperatures *below* 575°C consist of only two layers, magnetite and ferric oxide. These oxide scales are normally very brittle, and as the metal cools they crack, due to the difference between their coefficients of expansion and that of the metal. To increase the degree of cracking, the steel is sometimes flexed. Again, ***Armorhib CI-31*** regulates the scale removal process to minimize brittleness.

PLANT CLEANING

Inhibited acids are used extensively in plant cleaning; both pre-commission and periodic planned service cleaning. Many plants use acid cleaning, including breweries, dairies and sugar refineries, but the major use of acid cleaning is in power plants. In all application, the use of a corrosion inhibitor is necessary to maximize the cleaning effect, while minimizing any unwanted corrosion.

Pre-commission cleaning removes welding slag, silica, rust, oil, grease and other matter from new boilers. It is impossible to mechanically clean many inaccessible boiler parts once the final unit has been manufactured. Therefore, an acid-flush is necessary to clean the tubes. Any impurities left in the boiler can cause blockage of strainers and serious damage to turbine blades. Boilers that have not been cleaned, prior to commissioning, can have up to ten percent loss of generating power.

Hydrochloric acid solutions are used in pre-commission cleaning. However, citric acid is preferred for austenitic steels (e.g. superheaters), since it is thought that chloride ions might cause stress corrosion. Where copper or copper alloys are present, citric acid solutions are also preferred.

Service cleaning serves to remove hard scales and deposits formed during steam generation. These deposits reduce heat transfer from the boiler. The absolute minimum attack of acid on metal must be ensured, and the type of scale encountered (high in carbonates) does not need attack on the base metal to aid its removal. The purpose of the inhibitor is, if possible, to prevent any attack at all. Acid cleaning is followed by neutralization and passivation processes, aimed at producing a thin protective layer of magnetite on the clean metal surfaces.

Hydrochloric acid is the acid most often used for plant cleaning, although sulfamic, sulfuric, citric and phosphoric acids are also used. The appropriate **Armohib Cl-28 or Cl-31** product will serve the corrosion inhibiting needs of any of the acid applications.

Armohib Cl-28 is used to create efficiently inhibited hydrochloric solutions for hydrochloric applications for steels such as admiralty, carbon steels, cast iron, copper and its alloys such as monel, brass, bronze, cupro-nickel and chrome-molybdenum.

Sulfamic acid is often used as an alternative to hydrochloric acid. While sulfamic is more expensive per pound, the quantity required for a given operation is considerably less, so that overall costs per application are lower. Sulfamic acid, inhibited with **Armohib Cl-31**, is used to clean deposits from 300 and 400 series stainless steels and occasional cleaning of aluminum and its alloys. Sulfuric acid is also not as sensitive to contamination as hydrochloric acid. Inhibited sulfuric acid is used for cleaning 300 and 400 series stainless steels.

OIL WELL ACIDIZING

In the fracturing and acidizing of compact oil formations, dilute hydrochloric acid is used to dissolve the undesirable carbonate deposits or scales, which interfere with the passage of oil, in tubing or in the formation itself.

The lines and tubing must be protected during this operation from corrosive attack by the acid, by the high temperatures and pressures, and by the potential for a “sour” environment resulting from the high hydrogen sulfide and carbon dioxide contents. **Armohib CI-28** used at a concentration of 0.25%, based on the total hydrochloric acid solution, is highly recommended for this purpose. It provides effective protection at temperatures in excess of 230°F (110°C) for at least 6 hours.

AMOUNT OF INHIBITOR NEEDED TO ACHIEVE USE CONCENTRATIONS

Armohib corrosion inhibitors may be added to either dilute or concentrated acid solutions. Never dilute the Armohib concentrates with water, as they will separate.

Dilute Acid Solutions: To obtain the inhibitor concentrations listed below, add approximately the indicated amounts of inhibitor to each 100 gallons of dilute acid solution.

Concentration %	Fluid Ounces Per 100 Gallons	Concentration %	Fluid Ounces Per 100 Gallons
0.01	1.5	0.14	21
0.02	3	0.15	22.5
0.03	4.5	0.16	24
0.04	6	0.17	25.5
0.05	7.5	0.18	27
0.06	9	0.19	28.5
0.07	10.5	0.2	30
0.08	12	0.21	31.5
0.09	13.5	0.22	33
0.1	15	0.23	34.5
0.11	16.5	0.24	36
0.12	18	0.25	37.5
0.13	19.5	0.26	39

Concentrated Acid Solutions: *Armohib* corrosion inhibitors can be used to prepare inhibited concentrates, which may be diluted with water to the desired concentration at the point of use. The conversion table presented below indicates the amounts of inhibitor to be added to 100 gallons concentrated acid to achieve a final concentration in a specific percent diluted acid solution.

For example: To obtain a 15% acid solution containing 0.03% *Armohib CI-31*, add 30 fluid ounces of the inhibitor to each 100 gallons of the concentrated acid. At the time of use, 15 gallons of this inhibited concentrate can be added to 85 gallons of water, to obtain the 15% inhibited acid.

Amount of Armohib Product Required per 100 gallons of concentrated acid that will be later diluted to the solutions shown:

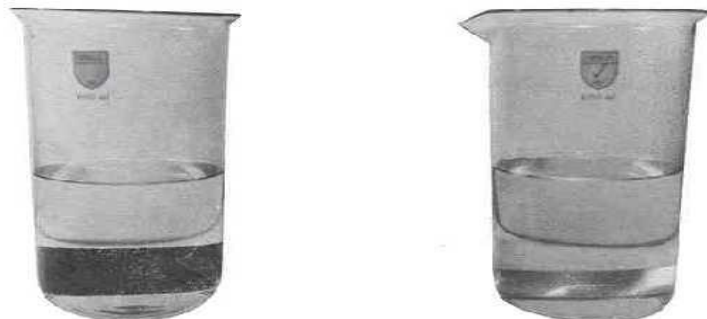
Armohib Concentration, % Total Dilute Acid Solution	5% Acid	10% Acid	15% Acid	20% Acid
0.01	30	15	10	7.5
0.02	60	30	20	15
0.03	90	45	30	22.5
0.04	120	60	40	30
0.05	150	75	50	37.5
0.06	180	90	60	45
0.07	210	105	70	52.5
0.08	240	120	80	60
0.09	270	135	90	67.5

NOTE: The information on this page concerning CONCENTRATED ACID SOLUTIONS is based on 100 weight percent acid. For acids less than 100%, the amount of inhibitor added is decreased. For example, multiply the ounces inhibitor by 37%, when using a hydrochloric acid solution which has a weight percent of 37 in HCl. Less water is needed to dilute a solution that is already less than 100%.

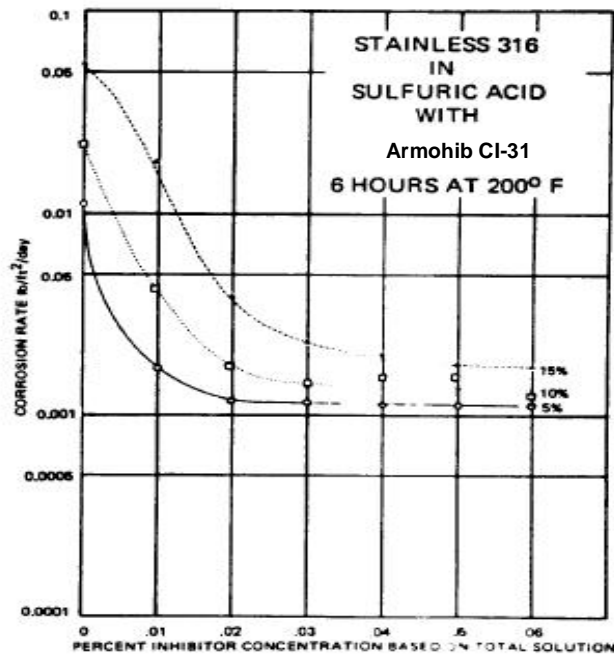
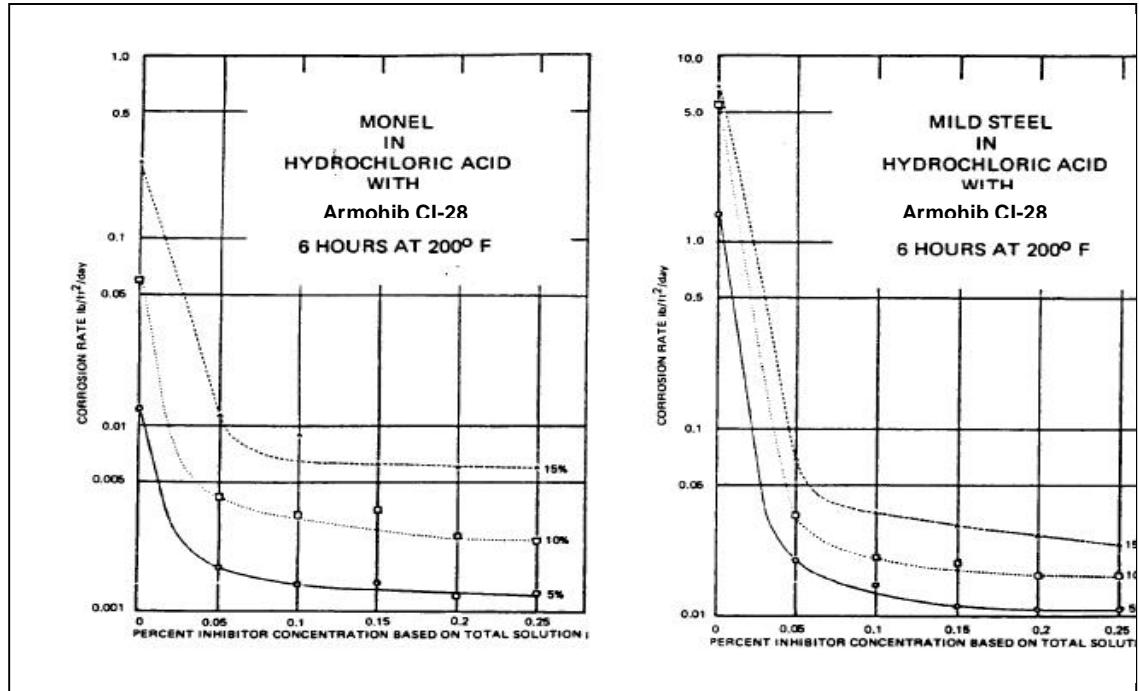
Corrosion Rate Graphs: Laboratory tests were made by exposing clean, shiny metal coupons to various concentrations of acid and inhibitor and varying temperatures for six hour periods. After exposure, the coupons were rinsed, cleaned, dried and reweighed. Corrosion rates were calculated by weight loss. Visual observations were made for discoloration. To convert corrosion rates from lb/ft²/day to gm/cm²/day, multiply by 0.49.

Typically, corrosion rate decreases logarithmically with increasing concentration of inhibitor. Note that the graphs use a semi-logarithmic scale.

The concentration of inhibitor to be used depends not only upon the acid, the metal to be cleaned, the concentration of acid and the temperature of the acid solution, but also upon the degree of protection required. Corrosion rates of mild steel (SAE 1010) are given for all inhibitors.

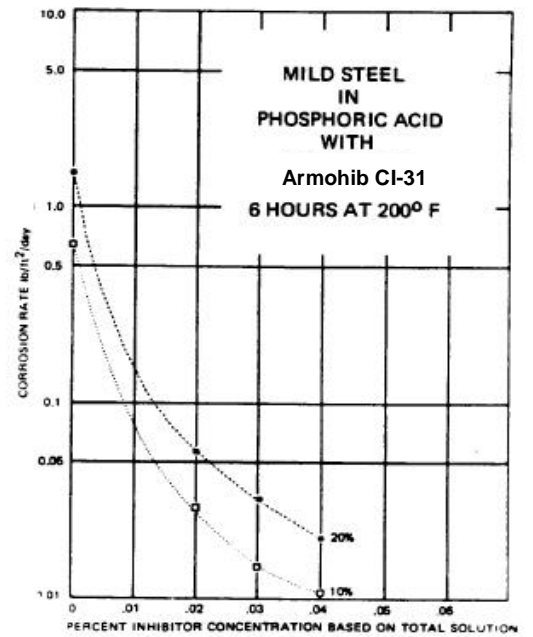
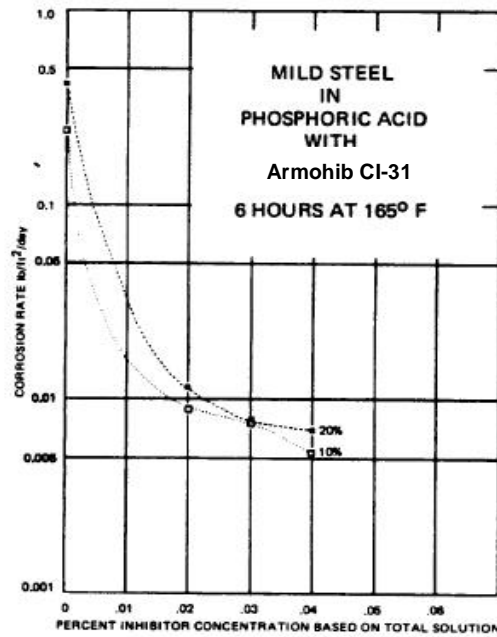
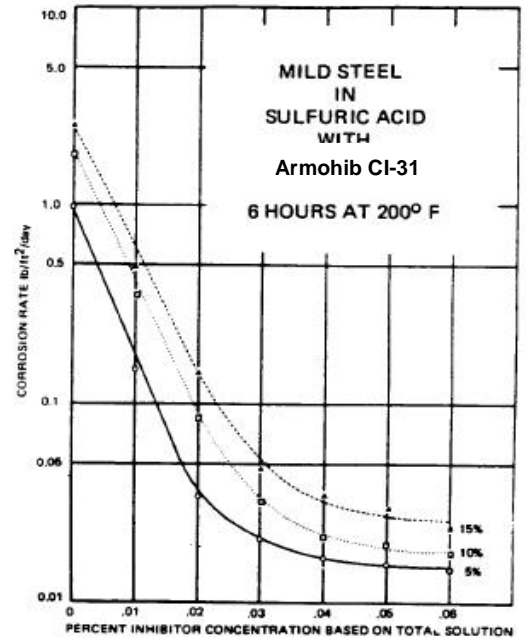
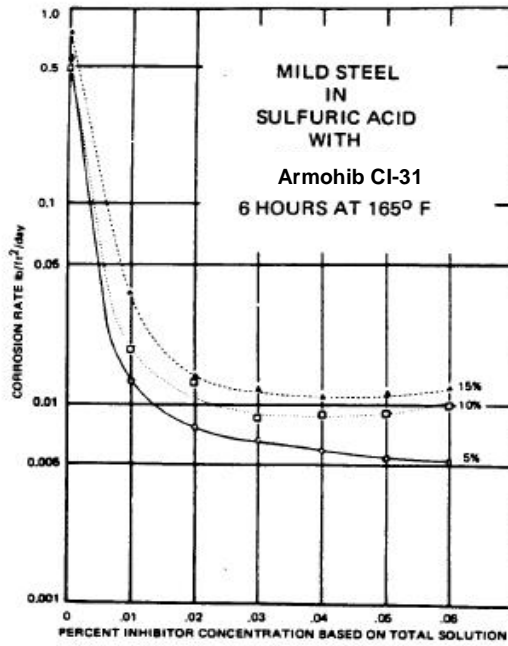


Laboratory demonstration of *Armohib CI-31* efficiency in hot sulfuric acid solution. Steel coupon in uninhibited acid in left hand beaker shows excessive attack and hydrogen evolution. Coupon, in acid inhibited *with *Armohib CI-31*, in right hand beaker shows bright surface with no acid attack.



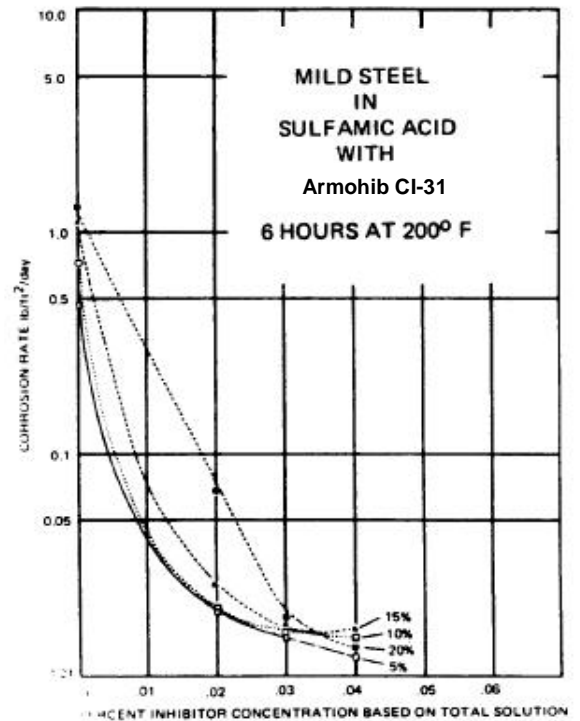
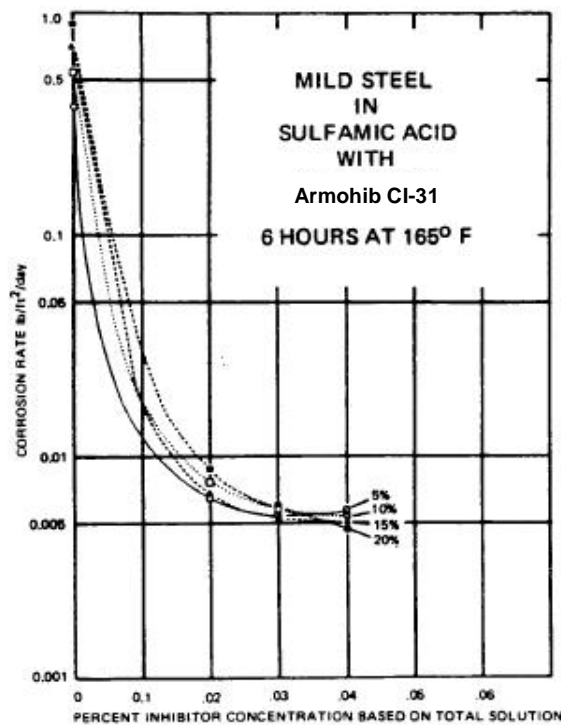
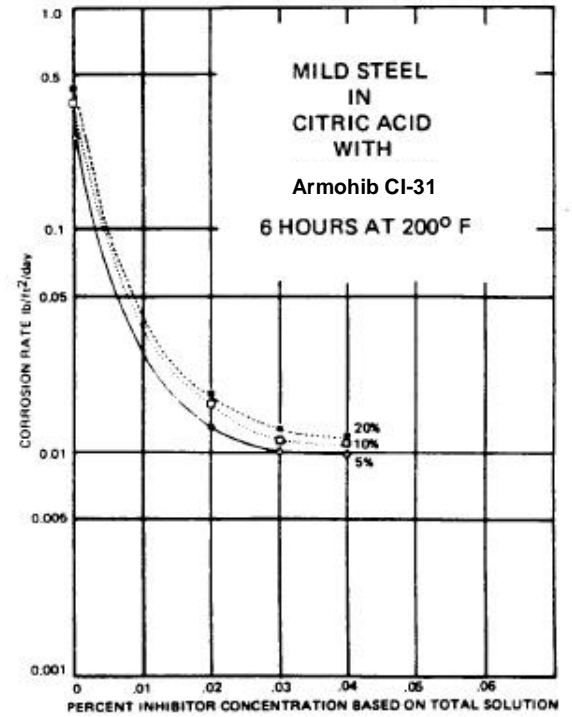
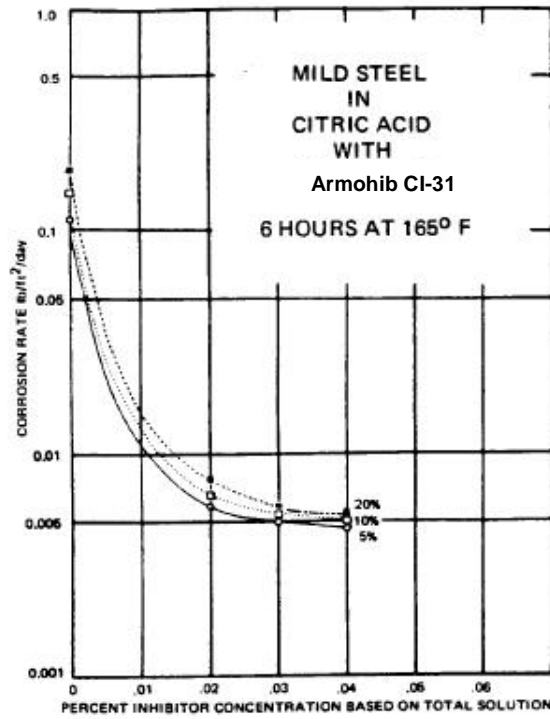


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HANDLING AND STORAGE

Armohib corrosion inhibitors are classified as hazardous chemicals, and care should be taken in their use. Gloves and goggles should be worn, since they are skin and eye irritants. In case of contamination, the area should be wiped with a cloth, in order to remove excess chemical; flushed thoroughly with water and washed with soap and water. A doctor should be called for major or prolonged skin irritation, ingestion, or contamination of the eyes.

Normal precautions should be taken in the storage of these chemicals. They should be kept in a dry place, away from heat.

AVAILABILITY AND SAMPLES

Armohib corrosion inhibitors are available in tight head 55 gallon steel drums with bungs.

Armohib© CI-28 & Armohib CI-31

Products for corrosion inhibition

Customer Service

For additional information, samples or assistance please contact your local sales representative or the Akzo Nobel Customer Service Department at:

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