

# ALUMINIZED STEEL TYPE 2

## PRODUCT FEATURES

Technical Bulletin

### MANUFACTURING

Steel strip is hot-dipped in a bath of molten, commercially pure aluminum. Controlled processing results in a durable bonded coating of controlled thickness.

### COATING MICRO-STRUCTURE

A duplex aluminum/aluminum-iron alloy coating provides a double line of defense against corrosion. The coating is tightly bound to the steel substrate and closely controlled for thickness and uniformity.

### BASIC COATING CORROSION BEHAVIOR

A passive aluminum layer resists corrosion arising from dissolved oxygen, CO<sub>2</sub> and high velocity waters. The alloy provides backup abrasion/erosion resistance while inhibiting pit growth.

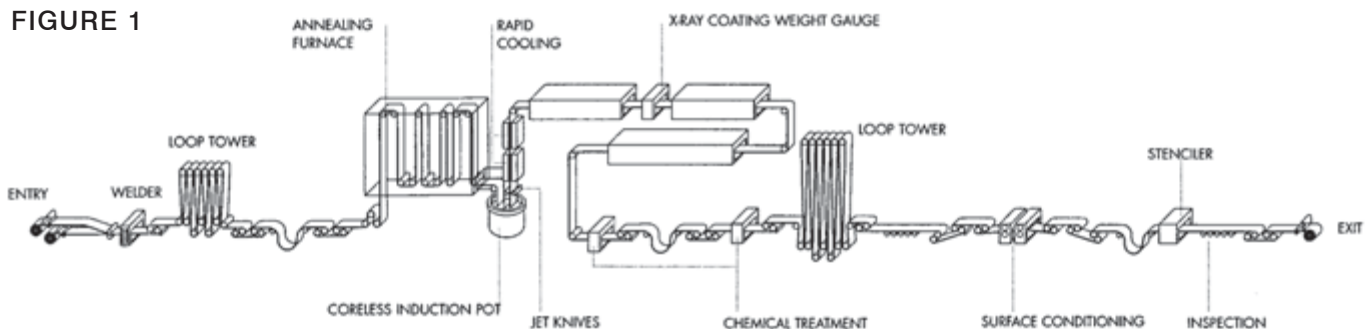


Aluminized Steel Type 2 was developed for superior environmental corrosion resistance.

### MANUFACTURING

Aluminized Steel Type 2 is produced by continuous hot-dip coating of steel strip in a bath of molten, commercially pure aluminum. Cleaning the strip in a non-oxidizing/reducing furnace atmosphere assures a pristine surface for coating adherence. Interaction of molten aluminum with the steel surface produces a metallurgical bond and provides corrosion protection. Line speed, bath temperature and air finishing knives control aluminum coating thickness.

FIGURE 1



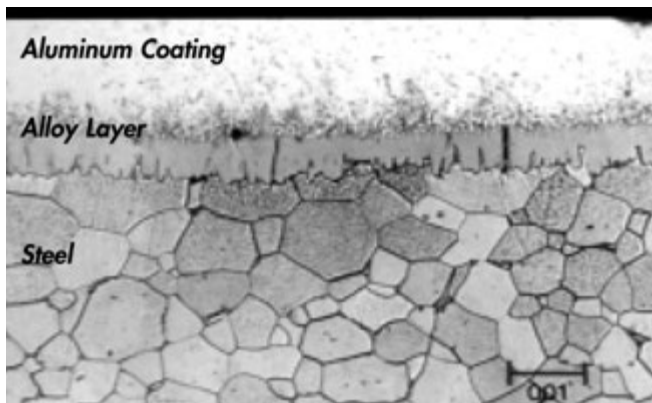
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## Product Description

### COATING MICROSTRUCTURE

The Aluminized Steel Type 2 coating microstructure is comprised of two layers: an aluminum layer and an underlying hard aluminum-iron intermetallic alloy layer. The alloy arises from interaction of molten, commercially pure aluminum with the steel surface and is the agent that bonds the coating to the substrate. The alloy is an essential part of the coating protection system, supplementing the aluminum layer and providing a second line of defense to ensure long-term durability. Control of the alloy layer thickness and thickness uniformity assures the degree of coating formability necessary for corrugated steel pipe manufacture.

FIGURE 2



Photomicrograph of metallurgical bond showing aluminum and aluminum-iron alloy layers and steel substrate.

### BASIC COATING CORROSION BEHAVIOR

#### COATING CORROSION RESISTANCE

The aluminum spontaneously forms a passive oxide layer. This film imparts its usual high resistance to major environmental factors influencing corrosion behavior in waters and soils. Corrosion due to dissolved oxygen and carbon dioxide and erosion corrosion due to high velocity waters are the common influential factors in a pipe waterside environment. The passive layer imparts high resistance to all of these factors.

FIGURE 3



Coating Pit on 30-year old pipe demonstrating arrested pit penetration.

Any pitting in the aluminum layer will be arrested at the thick alloy layer. At the alloy layer, pits grow in width rather than in depth. The aluminum layer may exhibit abrasion losses in high velocity rainfall run-off carrying bedload but the alloy layer provides enhanced resistance to mild-to moderate abrasion. The alloy layer also resists erosion corrosion and corrosion by water and soil, providing effective long-term protection.

As a consequence of its combined coating properties, Aluminized Steel Type 2 achieves a superior service life over the full range of normal exposure conditions common to drainage pipe environments. Exceptions include severe abrasive conditions and severe corrosive conditions for example in seawater, acid minewater and sanitary sewage.

#### COATING PROTECTION MECHANISM OF THE STEEL SUBSTRATE

The very slow rate of pit growth observed in field surveys of pipe up to 50 years old is due to the galvanic protection mechanism of Aluminized Steel Type 2. Should pits penetrate into the steel substrate, three combined pit growth-restricting electrochemical factors are activated.

- Low-level (partial) galvanic protection of the pit cavity is provided by corrosion of the surrounding aluminum layer.
- The electrically insulating oxide films on the aluminum and alloy layers hinder the electrochemical action that powers pitting.
- Partial galvanic protection produces adherent corrosion products that plug pit cavities and retard corrosion.

All three electrochemical factors provide effective long-term substrate protection throughout the entire pipe service life.



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## About Cleveland-Cliffs Inc.

Cleveland-Cliffs is the largest flat-rolled steel producer in North America. Founded in 1847 as a mine operator, Cliffs also is the largest manufacturer of iron ore pellets in North America. The Company is vertically integrated from mined raw materials, direct reduced iron, and ferrous scrap to primary steelmaking and downstream finishing, stamping, tooling, and tubing. The Company serves a diverse range of markets due to its comprehensive offering of flat-rolled steel products and is the largest supplier of steel to the automotive industry in North America. The Company is headquartered in Cleveland, Ohio with mining, steel and downstream manufacturing operations located across the United States and in Canada. For more information, visit [www.clevelandcliffs.com](http://www.clevelandcliffs.com).



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