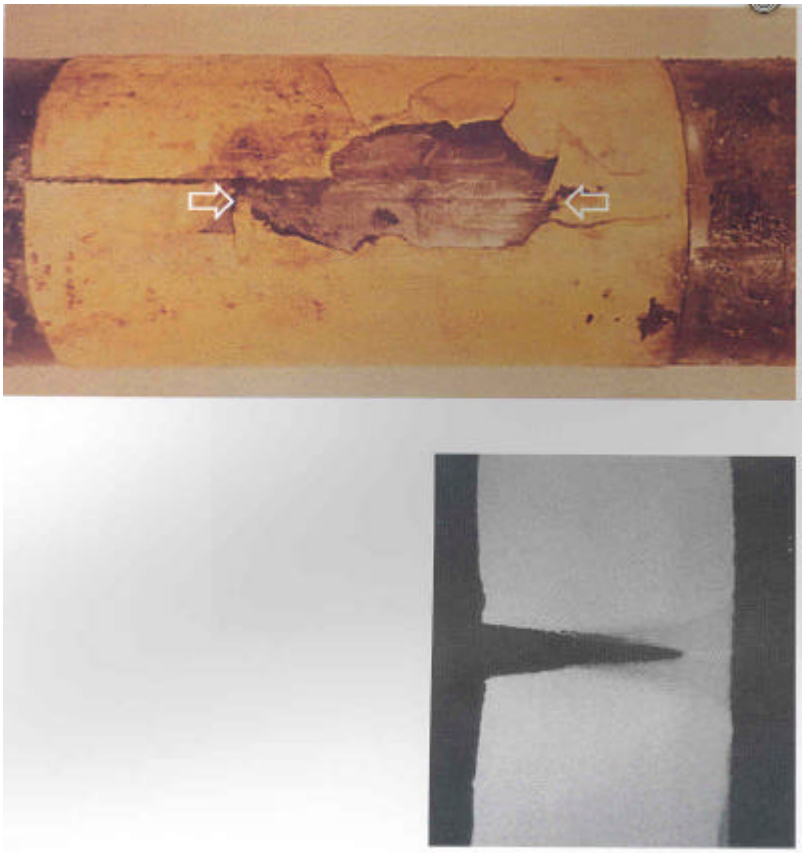
LACK OF FUSION



Description

Axial, crack like, planer faults at the mid point of the weld.

Cause

Incorrect welding parameters, for example low welding current input which leads to insufficient resistance heating at the joint line.
Lack of fusion may be associated with burn marks on the outer surface of the pipe.

Comment

Ensure good maintenance and operation of the pipemaking equipment in the mill.

Replace pipe or install repair clamps or repair shells as appropriate.

LAPS

Description

A flap of metal lying flat on the pipe surface, usually with a trapped residue of oxide or scale beneath it.

Cause

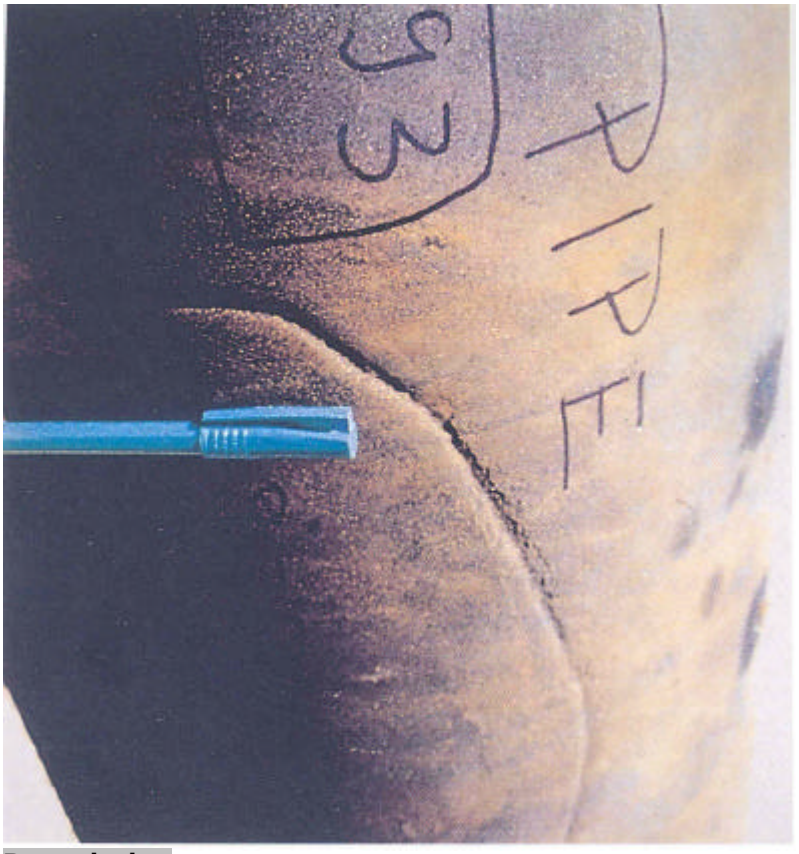
A metal protrusion that is folded and rolled into the hot metal surface during rolling of the plate from which the pipe is made.

Comment

Generally small laps have little or no structural significance. Laps to create holidays, or defects, in thin film coatings. Soluble salts trapped in the scale or oxides beneath the lap may initiate corrosion pitting.

Superficial laps may be removed by grinding before application of the coating.

DAMAGE AND CORROSION



Description

Corrosion of pipe steel exposed by mechanical damage.

Cause

Exposed steel will corrode if the applied cathodic protection is ineffective. Clean steel in gouges may be anodic to the surrounding pipe wall.

On above ground pipe areas exposed by mechanical damage will suffer atmospheric corrosion.

Comment

Ensure the applied cathodic protection is effective.

Assess the significance of the damage, check for cracks and apply an appropriate repair procedure.

GENERAL CORROSION

Description

Areas of irregular metal loss or pitting

Cause

Coating damage or disbanding combined with ineffective cathodic protection, for example due to shielding of the cathodic protection current under a disbanded coating.

General corrosion may also occur where soil contamination is entrained beneath a field applied coating.

Comment

General corrosion on exposed steel can be controlled by an effective cathodic protection system. General corrosion due to water ingress under a disbanded coating mat not be controlled by cathodic protection due to shielding effect of the coating. In this situation the corrosion problem can only be identified, reliably, by intelligent pig inspection.

MIC – MICROBIALLY INDUCED CORROSION

Description

Typically deep, sharp sided pits. Usually found under disbanded coating or hard accumulations on the pipe surface. When disturbed the area may smell of hydrogen sulphide.

The corrosion product within the pits is often soft, has no structure and is deep black in colour.

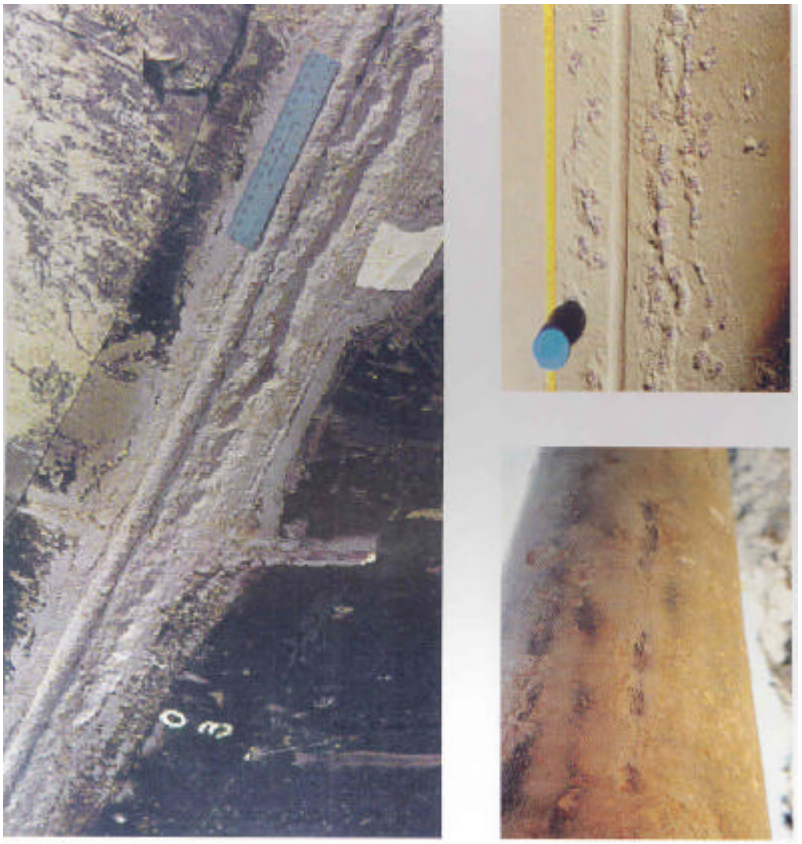
Cause

Bacterial activity in anaerobic conditions under the coating or surface deposit. The immediate area of microbial activity may be anodic to the surrounding pipe.

Comment

Ensure a good quality coating and polarize the pipeline to a minimum potential of –950 mV (with respect to a saturated copper-copper sulphate reference electrode) in anaerobic soils.

NAEC – NARROW AXIAL EXTERNAL CORROSION



Description

Narrow lines of axial pitting, most commonly on either side of a seam weld or spiral weld. This pattern of corrosion may also occur at 3 o'clock and 9 o'clock beneath wrinkles in the coating caused by soil loading.

Cause

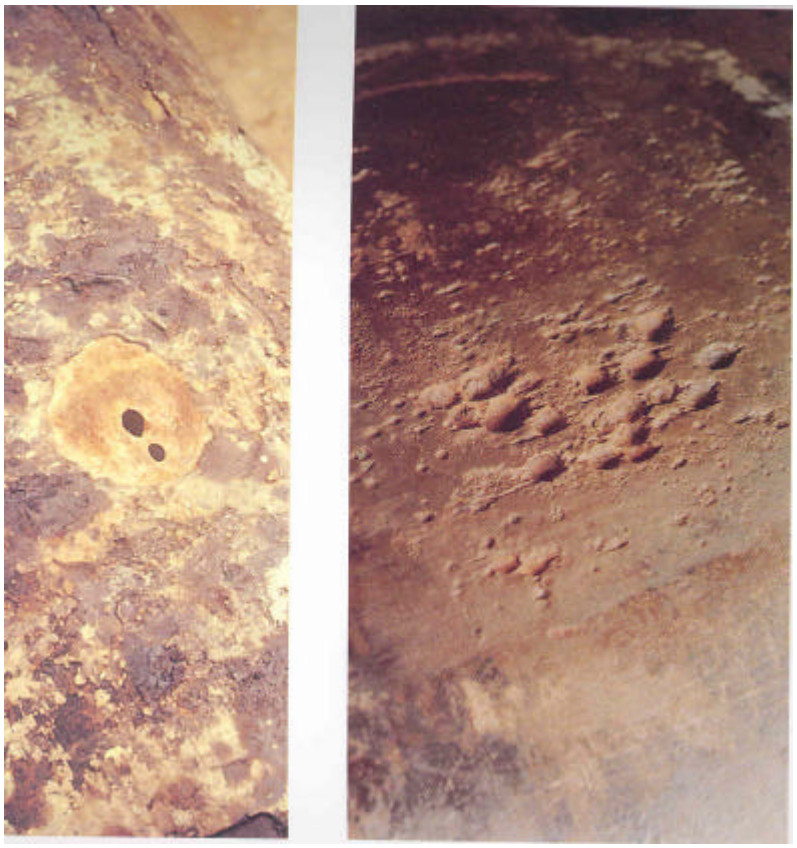
Bridging or tenting of coating, commonly field applied tape, over the seam or spiral weld. This leaves a void on either side of the weld bead which may become filled with water.

Comment

Ensure that the coating fully conforms to the external surface of the pipe.

Modifications to the applied cathodic protection may not be effective in controlling this form of corrosion because the coating this form of corrosion because the coating will prevent cathodic protection current access to the water.

Pitting



Description

Localised corrosion, typically at areas where the coating has suffered impact or stone damage.

Cause

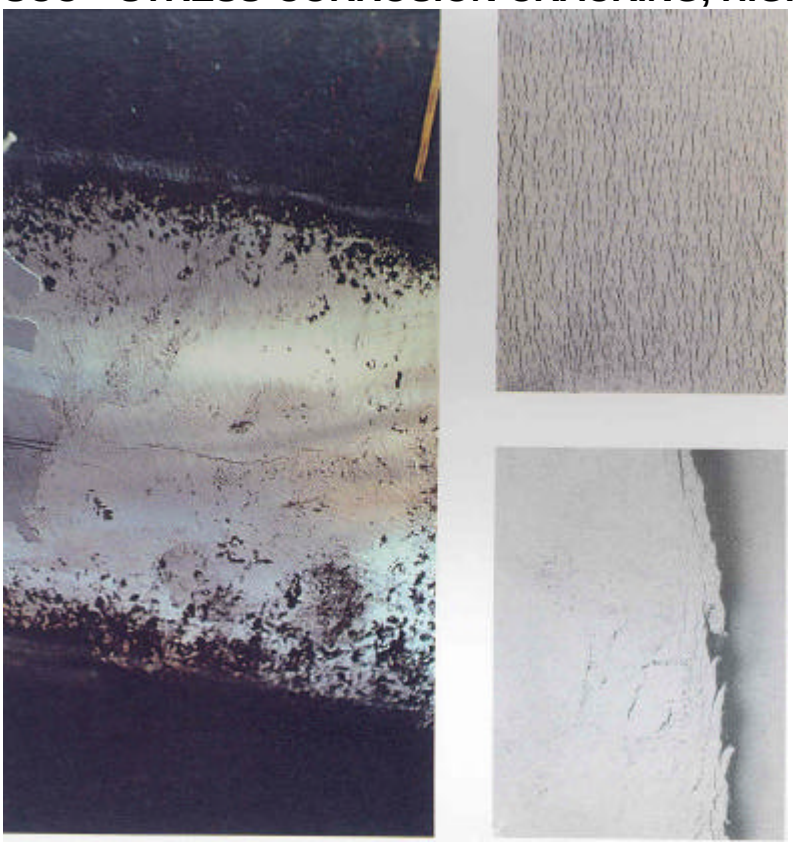
Damage to the coating and ineffective cathodic protection, for example where the pipe to soil potentials are less negative than –850 mV (with respect to a saturated copper – copper sulphate reference electrode).

Pitting may also be caused by microbial corrosion, stray current activity and galvanic effects.

Comment

Maintain pipe to soil potentials more negative than –850mV.

SCC – STRESS CORROSION CRACKING, HIGH



Description

Irregular, intergranular cracks that are most commonly aligned axially on the pipe. Cracks are not usually associated with any pitting or general corrosion.

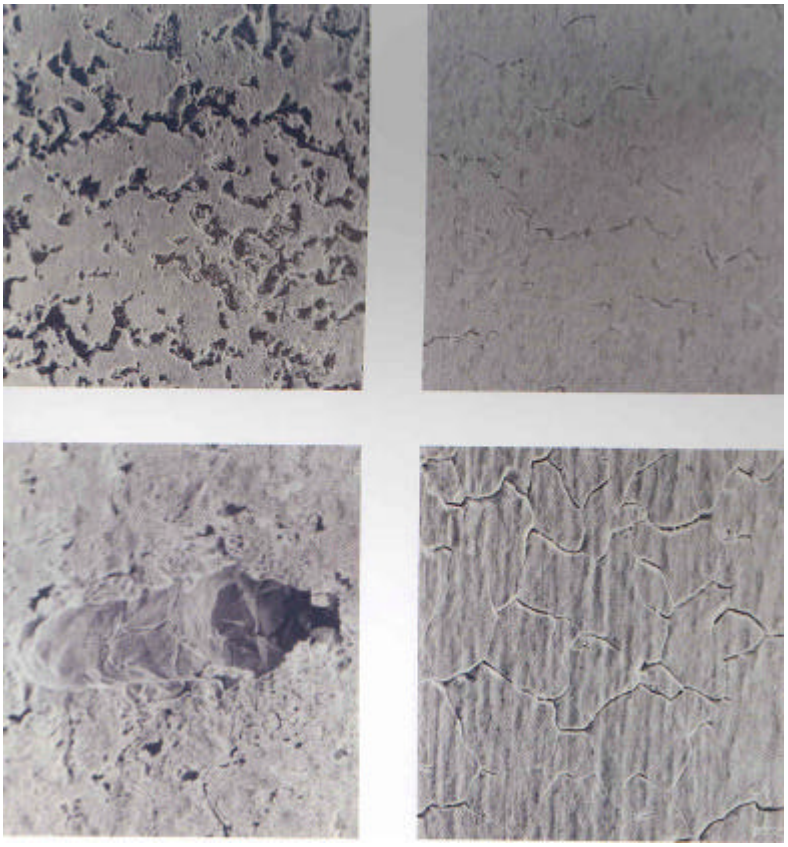
Cause

A complex array of factors contribute to the initiation and growth of high ph stress corrosion cracking including: high stress, pressure cycling, development of a carbonate – bicarbonate environment, partial shielding of the applied cathodic protection and permanent or seasonal wetness in the soil.

Comment

Limit the maximum operating temperature, within the performance of the coating, and control pressure cycling.

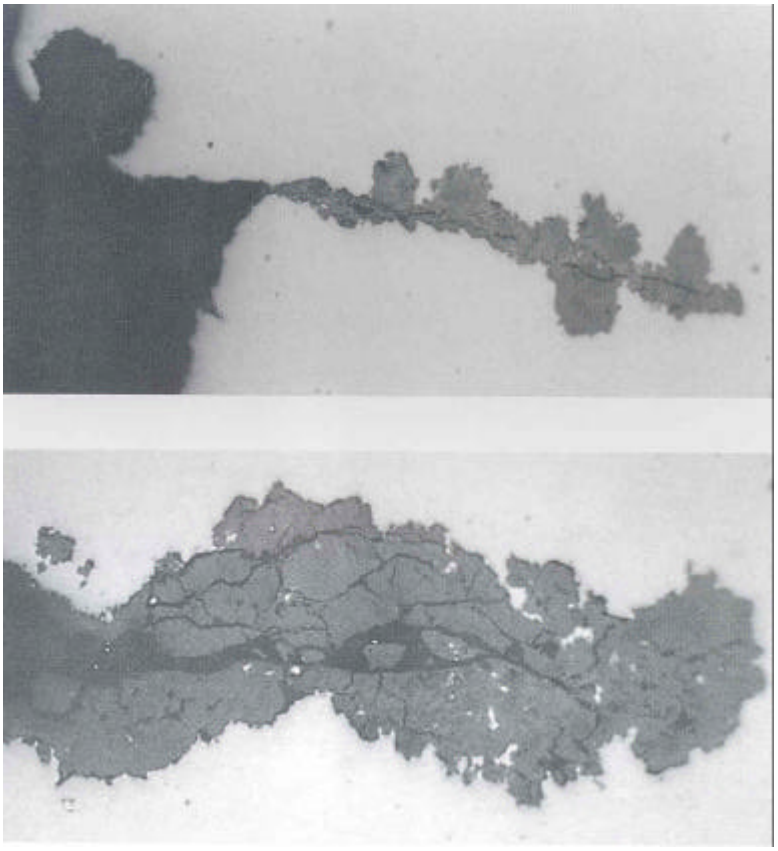
SCC – STRESS CORROSION CRACKING, INITIAL STAGES



Description

These photo micrographs show preferential corrosion and crack initiation at grain boundaries aligned at right angles to the principal, cyclic stress acting on the pipeline.

SCC – STRESS CORROSION CRACKING, NEAR NEUTRAL



Description

Axial, transgranular cracks that are typically oxide or scale filled. Cracks may occur in association with pits and general corrosion.

Cause

This form of stress corrosion cracking occurs where the pipe surface is shielded from cathodic protection current, for example by a delaminated coating. It is thought to be most prevalent in high latitudes where there is a marked seasonal change in the carbon dioxide content of the soil. Some pressure cycling is required for initiation and growth.

Comment

On affected pipelines areas of corrosion, which may be under disbanded coating, should be excavated and re-coated or fitted with a repair sleeve and re-coated as appropriate.

STRAY CURRENT

Description

Concentration of deep corrosion at one, isolated location on the pipeline where there is one, or more, coating faults.

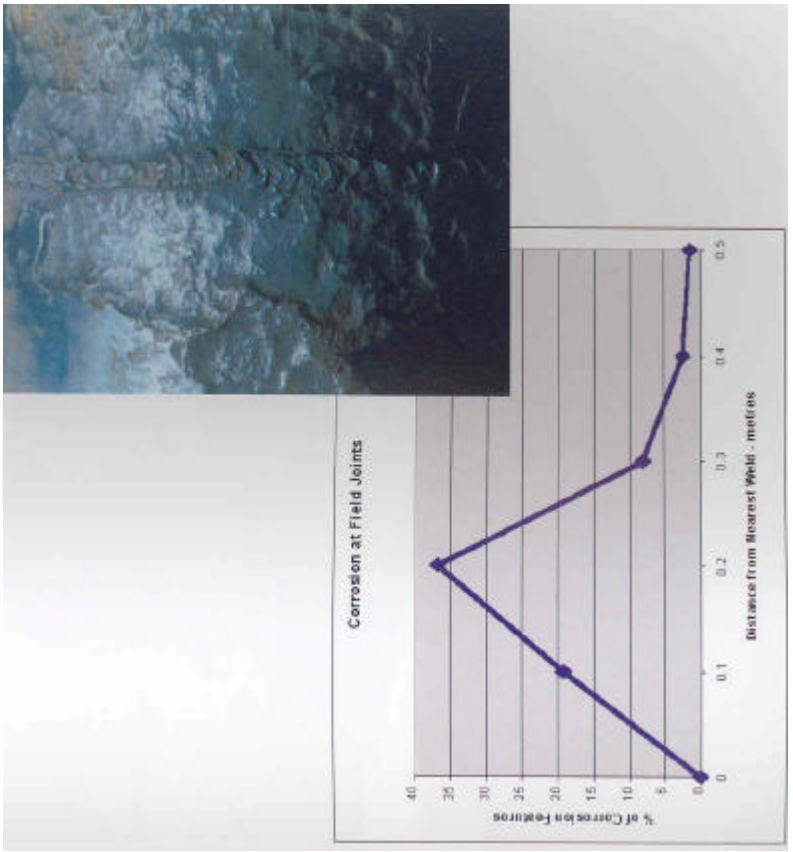
Cause

Discharge of stray current from the pipe to the soil. For example where the pipe provides a preferential flow path for electrical current.

Comment

Identify the origin of the stray current and eliminate it.
Record pipe potentials at suspect locations to check for periodic interference, such as passing trains with electrical drive systems.

WELD AREA CORROSION



Description

Corrosion limited to the immediate area of the field joint between the factory applied coating on the body of the pipe.

Cause

Problems with the quality of the field applied joint coating.

Comment

Good quality control or field joint coatings and coating procedures.

Modifications to the applied cathodic protection is unlikely to control this type of attack.

SEPARATIONS, CHARPY

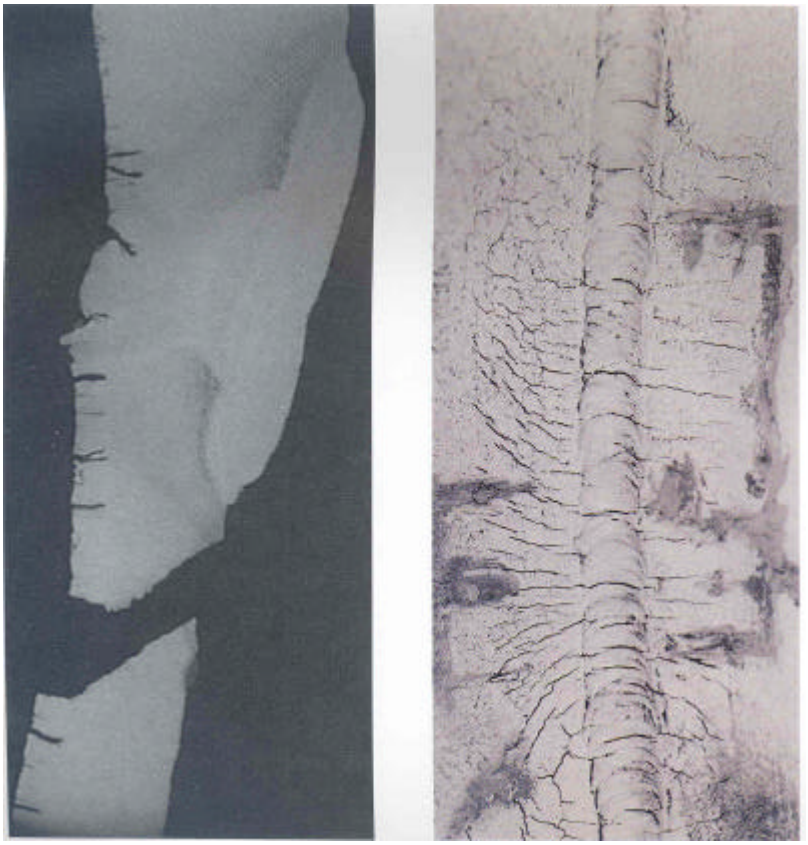
Description

Cracks, or crack like features that appear in the fracture face of mechanical test pieces.

Cause

Separations appear in Charpy, Crack Tip Opening Displacement and Drop Weight Tear Test pieces. Their occurrence may be influenced by steel chemistry and plate rolling conditions, particularly heavy deformation at low rolling temperatures. The crack like features are related to the steel structure, for example fine bands of martensite.

CO-CO2 SCC – STRESS CORROSION CRACKING



Description

Internal cracking aligned at right angles to the principal stress.

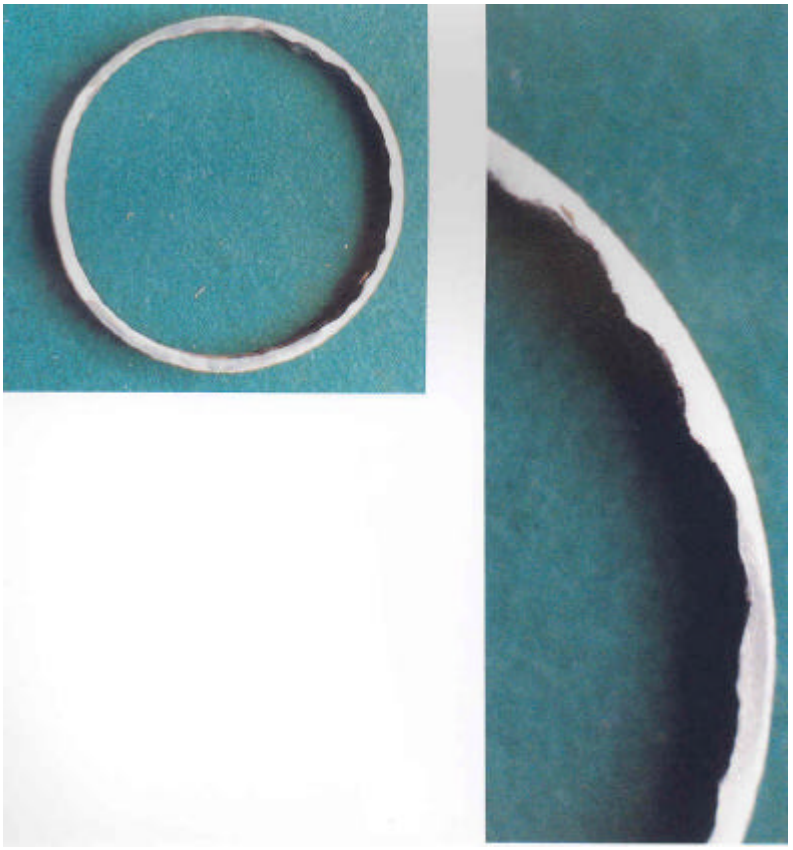
Cause

A protective layer is formed on the pipe surface by a monolayer of adsorbed carbon monoxide. This film is dislocated at grain boundaries and exposes he steel to localized corrosion by water containing carbon dioxide.

Comment

This is only a problem in ‘town gas’ or manufactured gas containing carbon monoxide, carbon dioxide and water. The minimum carbon monoxide concentration for crack initiation and growth is ~1 %. Oxygen may accelerate cracking if it is present at a concentrations of less than 2 %.

GENERAL



Description

Areas of corrosion with a large surface area compared to depth.

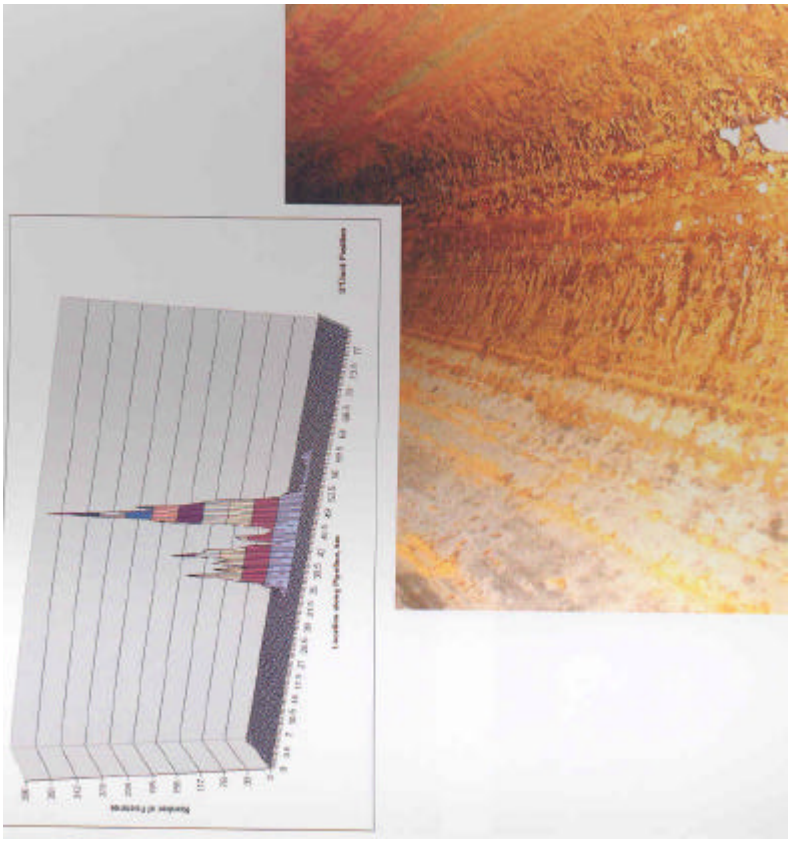
Cause

Usually evident in pipelines with an excess of water and no inhibitor treatment or ineffective treatment.

Comment

Remove the water or implement an effective inhibition programme.

GROOVING



Description

Narrow lines of pitting at the 6 o'clock position in a pipeline. The pits may join up to create an axial groove in the bottom of the pipeline.

Cause

Separation of water from the oil phase in products with a low water content, typically ~1%.

Comment

Long, linear defects may be structurally significant. Corrosion control may be possible by dosing the product with an appropriate inhibitor and routine pigging to remove the water phase.

HAZ – HEAT AFFECTED ZONE CORROSION

Description

Corrosion that is concentrated in a narrow band on either side of a weld, within the heat affected zone.

Cause

The heat affected zone is anodic to the pipe metal and weld metal. This forms a galvanic corrosion cell.

Comment

Ensure correct choice of welding consumable (not too highly alloyed). Post weld heat treatment may help.

HIC – HYDROGEN INDUCED CRACKING

Description

Mid–wall cracks that run parallel to the pipe wall. Cracks may join up, at different levels through wall cracks. Surface blisters may also contain cracks.

Cause

Hydrogen permeation from internal corrosion on sour service conditions. Atomic hydrogen diffuses into the pipe wall and hydrogen blisters form at inclusions. The gas pressure from these blisters generates crack growth.

Comment

Use a sour resistant steel

MESA

Description

Extensive, steep sided corrosion between areas showing little or no corrosion.

Cause

In high temperature conditions, above ~ 60 C, protective scales are formed in sweet conditions. If these scales are damaged in conditions where they cannot re-form, for example in turbulent flow regimes, rapid sweet corrosion occurs.

Comment

Additions of an appropriate corrosion inhibitor and control of flow rates below the limits for ersion (e.g. turbulence, cavitation etc.) can control this problem.

MIC – MICROBIALLY INDUCED CORROSION

Description

Commonly occurs as distinct, deep and steep sided pits.

Cause

Bacterial contamination of the product. Bacteria become active within slimes and deposits on the pipe walls.

Comment

Use an effective biocide treatment. If corrosion is active thoroughly clean the pipe surface before implementing the biocide programe.

PITTING

Description

Localized metal loss occurring in a random pattern.

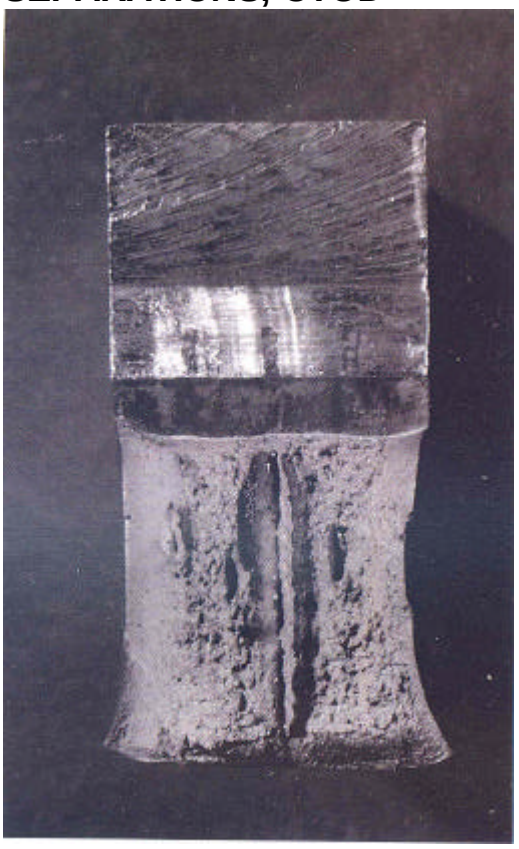
Cause

Pitting occurs where water is present as a separate phase. In gas pipelines this may be caused by water condensation from the gas phase where the pipeline is cooled, for example by exposure to the sea water. In oil pipelines it may be caused by water drop out.

Comment

Control of the gas humidity / dew point is the most effective control. Localized cooling, for example where a buried subsea pipeline has been exposed by erosion of the sea bed, may be controlled by placing mats over the pipeline. Inhibitor treatments can be effective if inhibitor transport to the affected area can be guaranteed.

SEPARATIONS, CTOD



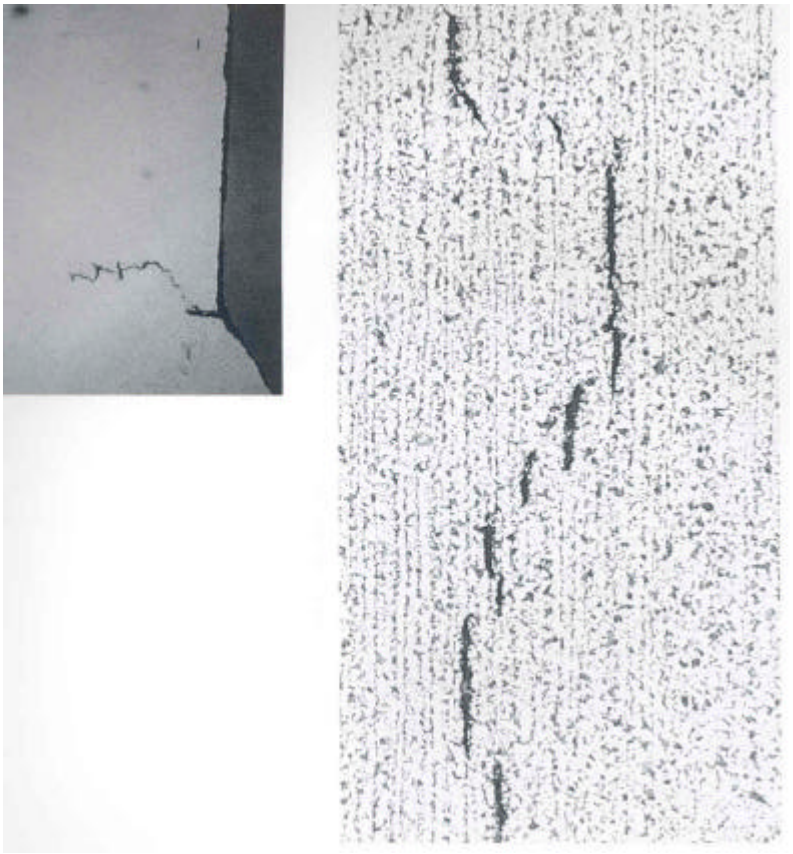
Description

Cracks, or crack like features that appear in the fracture face of mechanical test pieces.

Cause

Separations appear in Charpy, Crack Tip Opening Displacement and Drop Weight Tear Test pieces. Their occurrence may be influenced by steel chemistry and plate rolling conditions, particularly heavy deformation at low rolling temperatures. The crack like features are related to the steel structure, for example fine bands of martensite.

SOHIC – STRESS ORIENTED HYDROGEN INDUCED CRACKING



Description

Cracks that run parallel to the pipe wall that join up, at different levels through wall cracks. Can occur in softened regions of the weld heat affected zone.

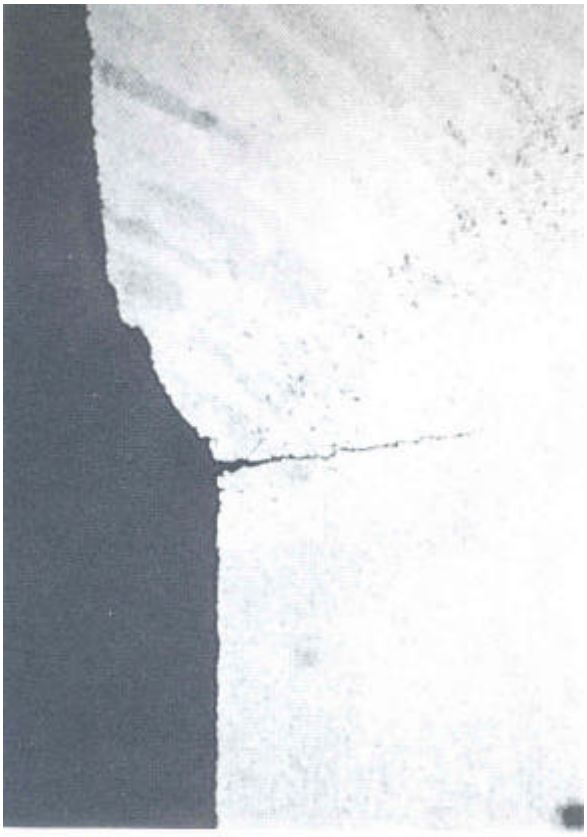
Cause

Hydrogen permeation from internal corrosion in sour service conditions. Atomic hydrogen diffuses into the pipe wall and hydrogen blisters generates crack growth. Cracks link together under the action of an applied stress, such as the operating pressure.

Comment

Use a sour resistant steel.

SSCC – SULPHIDE STRESS CORROSION CRACKING



Description

Through wall cracking at hard spots, such as the heat affected zone of girth welds.

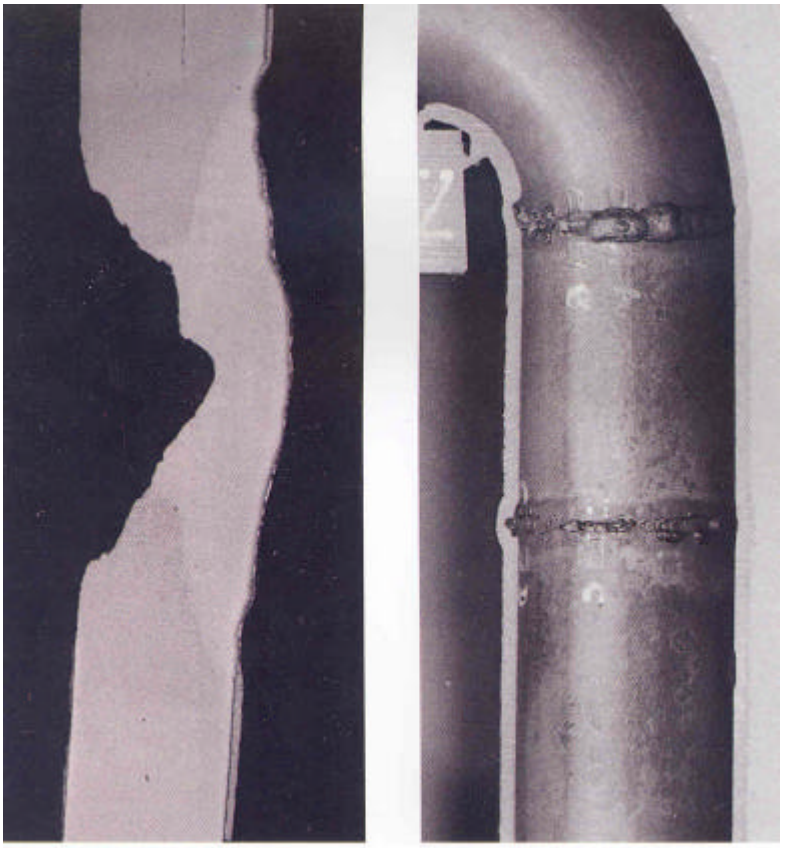
Cause

Hydrogen embrittlement of hard spots due to hydrogen diffusion from internal corrosion in sour conditions. Stress is required for crack growth, such as residual stresses within the weld.

Comment

Control girth weld hardness in line with the published criteria for sour service.

WELD CORROSION



Description

Preferential corrosion of the weld metal.

Cause

The weld metal is anodic to the pipe metal and this creates a galvanic cell. The cathodic surface area of the pipe is large compared to the anodic surface area of the weld so rates of attack may be rapid.

Comment

Use over-alloyed weld consumbles.

Operational: Erosion

EROSION CORROSION

Description

Localized, severe metal loss at location where the product flow is turbulent or where particles impact the pipe surface due to a change in direction of flow.

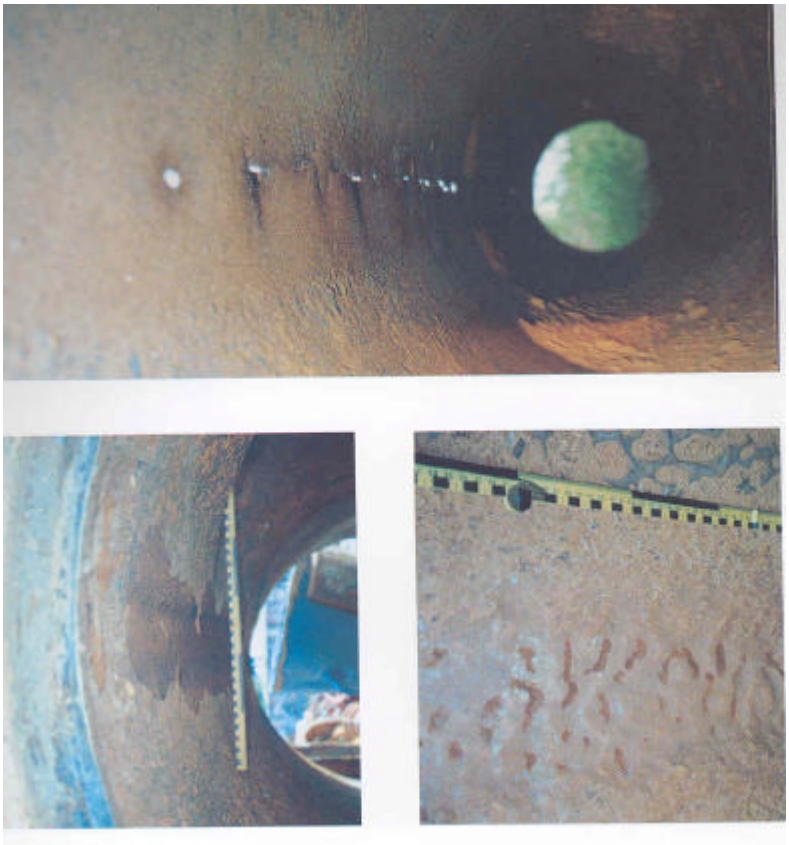
Cause

Turbulent flow (downstream of a valve or weld bead) or particle impingement removes surface films, scale or oxides to leave bright metal exposed. If this area is anodic to the adjacent pipe wall a galvanic corrosion cell will be formed.

Comment

Control the flow rate to avoid turbulence.
Remove particles.
Increase the wall thickness of vulnerable components .
Note that corrosion inhibitors will be ineffective because filming inhibitors will be stripped from the surface.

PARTICULATE EROSION



Description

Metal loss, usually concentrated at the 6 o'clock position.

Cause

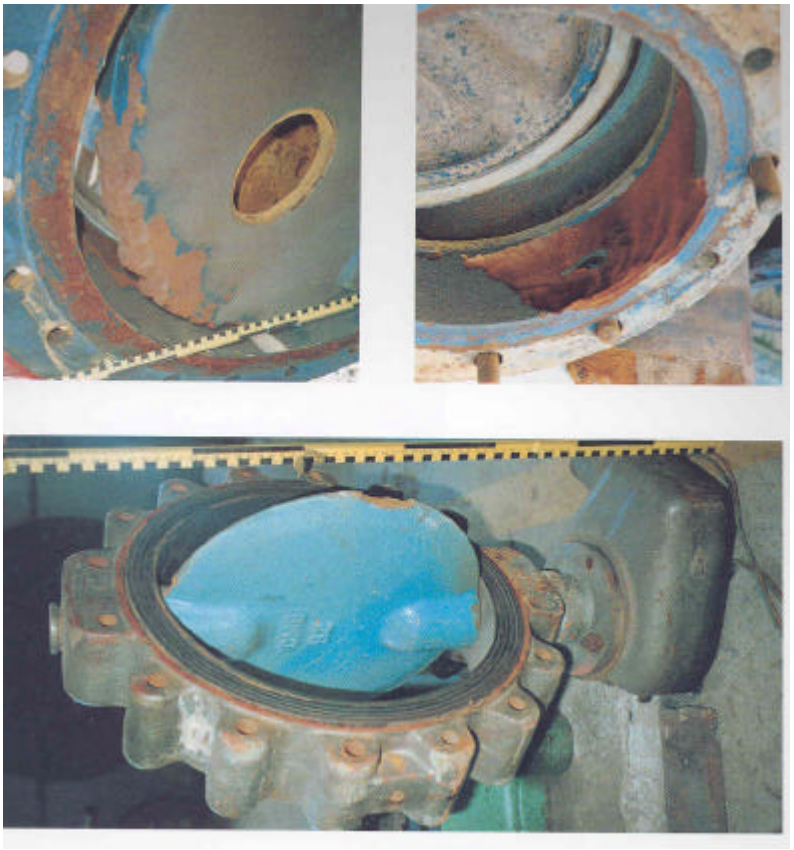
Particles of sand or scale are moved by the following product in a rolling or bouncing action. Impact by the particles may erode the pipe steel or destroy protective films and scales to allow erosion – corrosion.

Comment

Prevent ingress of particulate material. A similar pattern of metal loss may be generated by water drop out in low flow oil lines with a small water content (<1%).

Operational: Erosion

TURBULENT FLOW EROSION



Description

Severe, often localized, metal loss at locations where the product flow is disturbed.

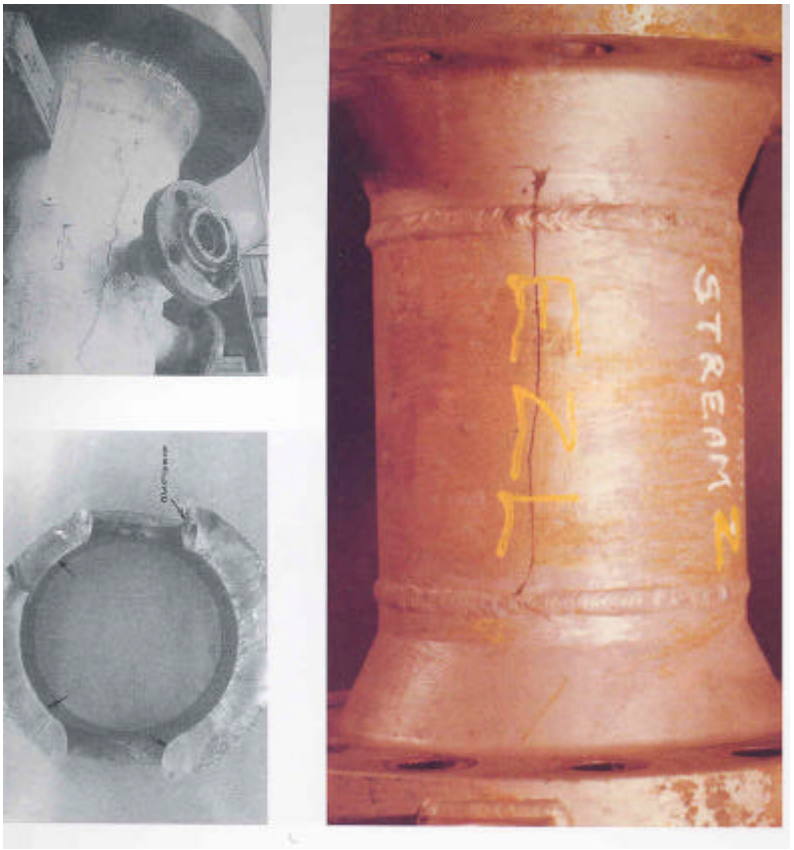
Cause

Constrictions in the flow, for example at a partly closed valve, create a pressure drop that may lead to cavitation. Disruption to the flow, for example by reduced bore valve, creates turbulence and increased velocity.

Comment

The rate of metal wastage can be rapid. Protective scales and corrosion inhibitor films will not control the metal loss. Reduce the overall flow velocity and eliminate flow restrictions, for example by inserting full bore valves.

FATIGUE



Description

Cracks aligned at right angles to the principal stress. Crack surfaces may show characteristic ‘beach marks’ that were formed at each stage of crack growth.

Cause

Cracks grow in response to stress, or pressure, cycling. Stress concentration occurs at the initiating defect or at the growing crack tip.

Comment

Reduce stress concentration by improved design and manufacturing techniques. Control the magnitude and number of operation pressure cycles.

Conduct a fatigue analysis to assess the risk of cracking.

DENT

Description

An indentation in the pipe wall.

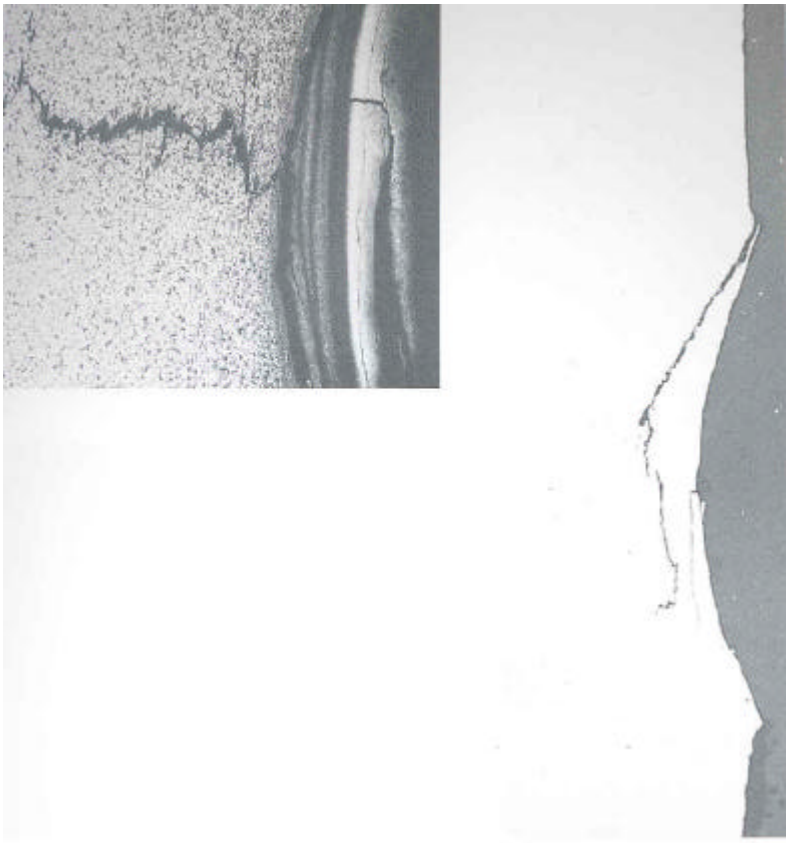
Cause

Severe impact from construction or agricultural equipment.

Comment

Measure the dent and carry out a structural assessment.
Cut out the damaged section and replace or repair.

GOUGE AND CRACK



Description

Irregular scores and gouging of the metal surface with cracking beneath the mechanical damage.

Cause

Mechanical damage by construction, excavation, drainage or agricultural equipment.

Comment

Carry out a full defect assessment and cut out or repair as appropriate.

GOUGE AND DENT

Description

Irregular scores and gouging of the metal surface contained within a dent.

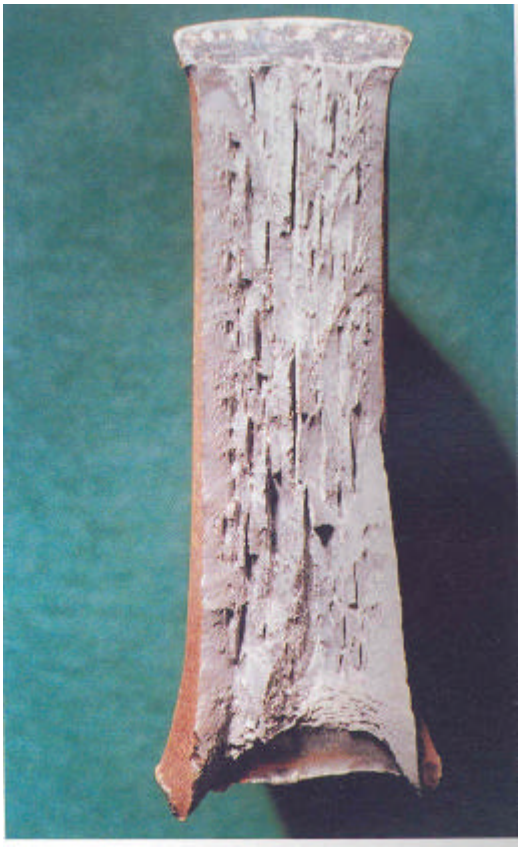
Cause

Mechanical damage by construction, excavation, drainage or agricultural equipment.

Comment

Carry out a full defect assessment and cut out or repair as appropriate.

SEPARATIONS, DWTT



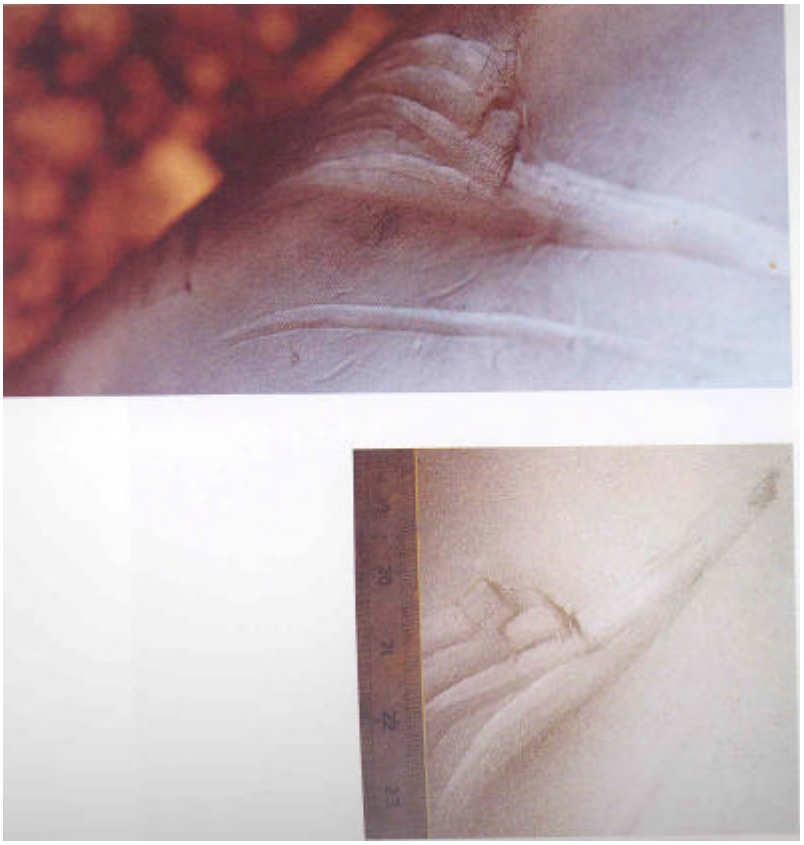
Description

Cracks, or crack like features that appear in the fracture face of mechanical test pieces.

Cause

Separations appear in Charpy, Crack Tip Opening Displacement and Drop Weight Tear Test pieces. Their occurrence may be influenced by steel chemistry and plate rolling conditions, particularly heavy deformation at low rolling temperatures. The crack like features are related to the steel structure, for example fine bands of martensite.

GOUGING



Description

Irregular scores and gouging of the metal surface.

Cause

Mechanical damage by construction, excavation, drainage or agricultural equipment.

Comment

Carry out a full defect assessment and cut out or repair as appropriate.

Operational: Mechanical Damage

PENETRATION

Description

Denting and penetration of the pipe wall.

Cause

Uncontrolled piling operations over the line of the pipeline.

Comment

Cut out and replace the affected section of pipe.

BUCKLE

Description

Deformation of the pipe.

Cause

High stress from transverse or longitudinal soil movement.

Comment

If soil movement or subsidence is detected assess the need to excavate the pipe and release the induced stress before damage to the pipe occurs. If damage has occurred then cut out and replace the pipe.

LANDSLIP

Description

Sudden bulk movement of soil downslope.

Cause

Instability due to mining or quarrying. Instability on slopes following heavy rain.

Comment

Movements may be severe and create gross deformation of the pipeline, for example buckling.

STRESS RELIEF

Description

Soil creep, landslips, subsidence, swallow holes etc.

Cause

Movement of the subsoil relative to the pipeline.

Comment

Excavate to fully expose the pipe throughout the area of soil instability.

SUBSIDENCE

Description

Sudden, localized collapse of the subsoil under a pipeline.

Cause

Collapse of rock or soil into underground cavities created by mining activity or by the solution of limestone bedrock.

Comment

Excavate the pipeline to relieve any stress concentration on the margin of the area of subsidence. Stabilize the pipe bed or re-route the pipeline through ground that is not affected.

WASHOUT

Description

Loss of backfill and the pipe bed

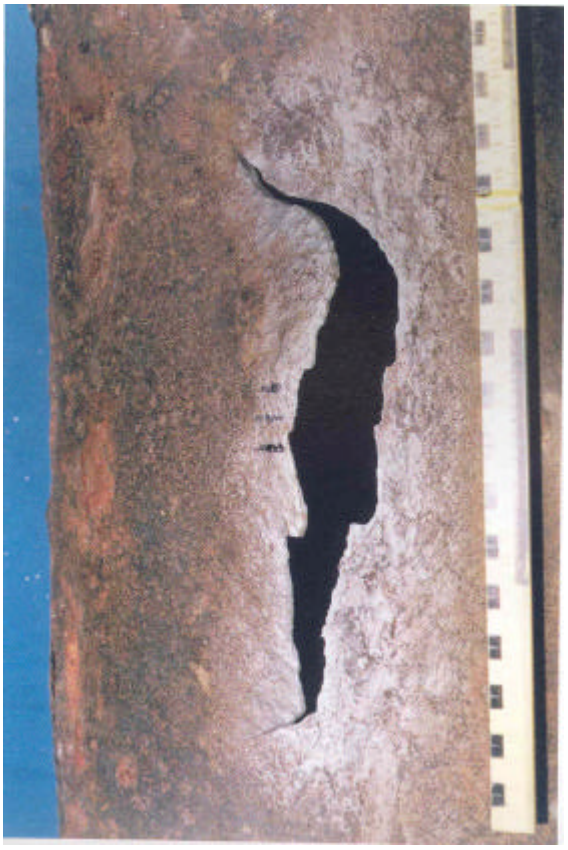
Cause

Severe erosion caused by flash floods.

Comment

Relieve any areas of stress concentration in the pipeline. Reinstate the pipe bed and provide protection against repeat washout or replace the section of pipeline

DUCTILE TEARING



Description

Localized tear or rupture through the pipe wall.

Cause

Ductile tearing of the remaining ligament of the pipe, wall in an area of severe corrosion, due to the internal pressure of the product.

Comment

The risk of failure initiation is greatest from long, axial defects. Conventional magnetic flux leakage pigs may not provide accurate sizing of long, narrow axial defects.

RUPTURE

Description

Sinusoidal fracture

Cause

Crack growth in a brittle pipe steel proceeds faster than the depressurisation front following the initial rupture

Comment

Assess the steel properties, such as toughness, to assess the risk of a propagating fracture.

SEAM WELD FAILURE

Description

Localized rupture

Cause

Failure caused by over-pressurisation or stress concentration at a defect.

Comment

Crack propagation will be made limited in a pipe steel with good toughness.

SLIVER

Description

A thin. Elongated flap of metal rolled into the pipe surface, often with oxide or scale trapped beneath it.

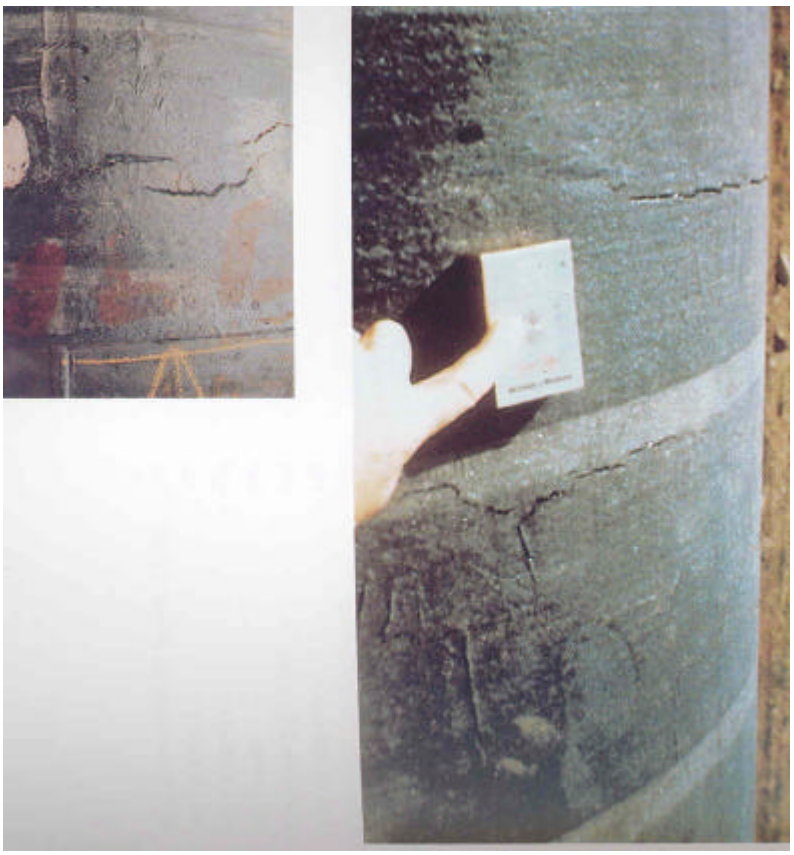
Cause

Rolling out of surface asperities, protrusions or solidified splashes of molten metal.

Comment

Small slivers are not structurally significant. Soluble salts contained within scale or oxides beneath the sliver may initiate pitting corrosion. Slivers also create holidays in thin film coatings. Superficial slivers may be removed by grinding before application of the coating.

COLD BEND CRACKS



Description

Irregular, circumferential cracks extending through the thickness of the coating.

Cause

Coating flexibility may be reduced at low temperature. If cold bending in the field is carried out at low temperature the coating may not have sufficient flexibility to tolerate the bending strain. If the coating adhesion is good cracking may result.

Comment

Ensure the coating has the required flexibility for cold bending and set a minimum temperature limit for bending operations.

Remove all loose coating and any contaminants on the pipe surface. Mechanically wire brush the substrate and coating and use a trowelling grade, two pack liquid urethane coating to fill the void and overlap onto sound coating.

COLD BEND DELAMINATION

Description

Complete loss of adhesion over large areas of the pipe surface.

Cause

Coating flexibility may be reduced at low temperature. If cold bending in the field is carried out at low temperature the coating may not have sufficient flexibility to tolerate the bending strain. If the coating adhesion is below standard then extensive delamination may occur.

Comment

Ensure the coating has the required flexibility for cold bending and set a minimum temperature limit for bending operations.

HIGH TEMPERATURE

Description

Brittle, degraded coating which may show cracking, wrinkling and porosity.

Cause

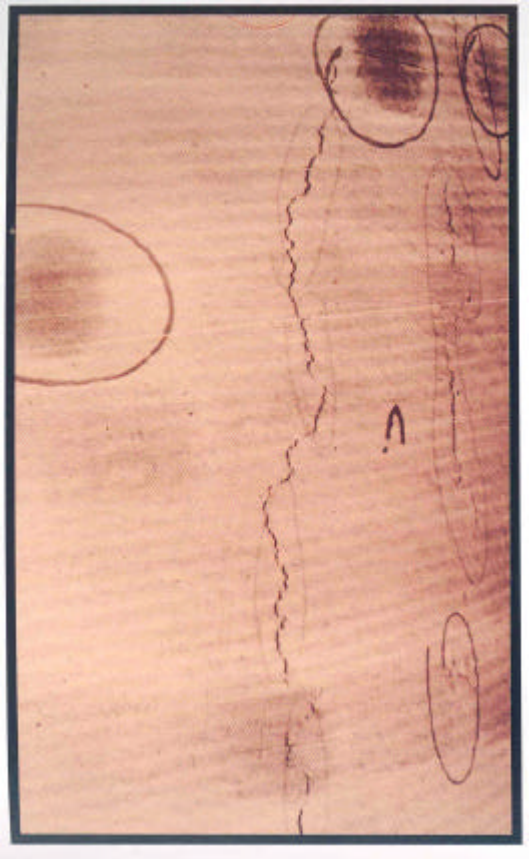
Brittleness and porosity may develop from loss of volatile constituents, such as plasticisers, at elevate temperatures.

Creep related degradation processes, such as wrinkling, proceed faster at higher temperatures.

Comment

Control product temperatures to a level below the softening point of the coating, especially at compressor or pumping station outlets.

HYDROSTATIC TEST CRACKS



Description

Irregular axial cracks through the coating.

Cause

Localized high strain during hydrostatic pressure tests at greater than 100% of the specified minimum yield strength.

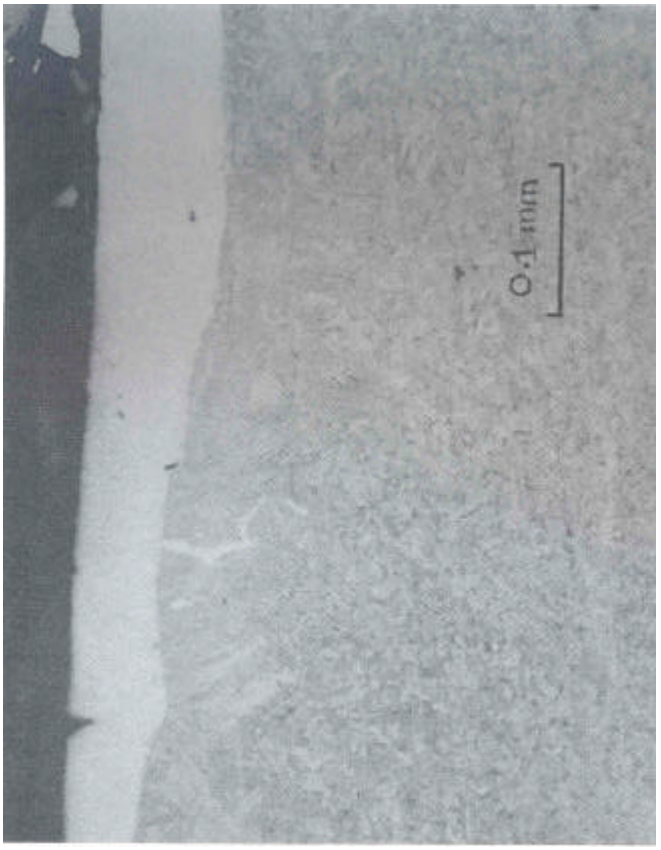
Cracking may be concentrated along crimp lines out into the plate during manufacture, for example along either side of the submerged arc weld in ‘U-and-O’ formed pipe, and on either side of the spiral weld in spiral welded pipe.

Comment

Ensure coating flexibility is adequate at the environment temperature and water temperature at the time of the hydrostatic pressure test.

Remove all loose coating and any contaminants lon the pipe surface. Mechanically wire brush the substrate and coating and use a trowelling grade, two pack liquid urethane coating to fill the prepared void and overlap onto sound coating.

COPPER PENETRATION



Description

Cracks like features normally at right angles to the pipe or plate surface.

Cause

Copper contamination occurs during the Pilger Mill process, for example following external contamination from defective equipment. Copper on the pipe surface penetrates into grain boundaries and forms a line of weakness that may open up, into crack like features, under stress.

Comment

In extreme cases the cracks can extend through the pipe wall.

Copper cracking should be detected by the Quality Control and pipe inspection procedures in the pipe mill.

IMPACT DAMAGE

Description

Complete loss of adhesion around the point of impact.

Cause

High energy impact from rocks or equipment exceed the performance specification for the coating. Under such impact conditions hot enamels may show brittle behaviour.

Comment

Avoid impact from construction equipment and remove large rocks and stones from the backfill. In rocky areas use a selective backfill all around the pipe.

Remove loose coating and any contamination. Repair using a two pack liquid urethane or a full encirclement heat shrink, wrap around sleeve after appropriate surface preparation.

MECHANICAL DAMAGE

Description

Scores or damage to the coating with possible loss of adhesion around the area of mechanical damage.

Cause

Civil engineering works such as excavation plant operating above the pipeline, or agricultural contractors engaged in sub-soiling or drainage activities.
Damage from heavy plant during handling and ditching of pipe at the time of construction.

Comment

Mark the location of the pipe and monitor adjacent civil engineering works in accordance with the appropriate code of practice.
For areas where the coating is not damaged through to the substrate repair by the use of a hot trowel or spatula. Where the metal substrate is exposed remove all loose coating and any contaminants on the pipe surface. Mechanically wire brush the substrate and coating and use a trowelling grade, two pack liquid urethane coating to fill the void and overlap onto sound coating.

SOIL LOADING

Description

Irregular cracking of the coating on the crown of large diameter pipe that extends through to the metal. Linear wrinkles, parallel to the pipe axis, as the 3 o'clock and 9 o'clock position. The wrinkles may be filled with water.

Cause

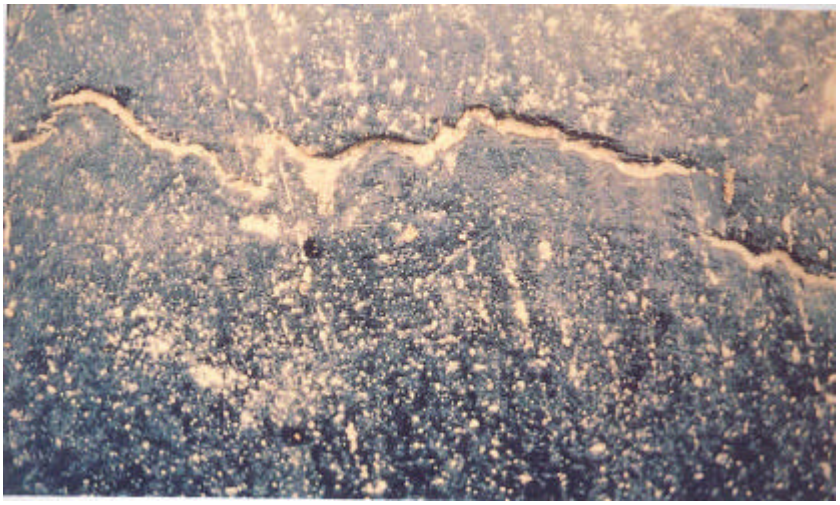
Settlement of the backfill, after construction, generates a tensile load in coating on the top half of large diameter pipe. Coatings that are susceptible to creep may develop cracks, wrinkles or both in response to this applied tensile load.

Comment

Use coatings that are not susceptible to creep. Overwrap the primary corrosion protection coatings with an adherent, low friction coating. Overwrap with a loose, deformable protective layer, but this layer MUST NOT interfere with CP current to the pipe.

Strip all areas of coating that show loss of adhesion or voids and all areas with moisture beneath the coating. Re-coat with a compatible, two pack liquid repair system after appropriate surface preparation.

SOIL STRESSING



Description

Irregular cracking and wrinkling of the coating with possible loss of adhesion.

Cause

Some heavy clay soils expand on wetting and contract on drying. These seasonal expansion and contraction movements may be transferred from the clay to the pipe coating. In coatings that are susceptible to creep this may result in tearing, wrinkling and loss of adhesion.

Comment

Use coatings that are not susceptible to creep. Overwrap the primary corrosion protection coatings with an adherent, low friction coating. Overwrap with a loose, deformable protective layer, but this layer MUST NOT interfere with CP current access to the pipe. Strip all areas of coating that show loss of adhesion or voids and all areas with moisture beneath the coating. Re-coat with a compatible, two pack liquid repair system after appropriate surface preparation.

STONE DAMAGE

Description

Irregular shaped holes in the coating, possibly in association with delamination or disbonding.

Cause

High point loads from stones standing proud of the pipe bed. If the profile of the pipe bed is irregular stone damage will be concentrated at high points.

Comment

Grade the pipe bed before ditching the pipe and use some form of padding or protection in stony ground. If the damage does not expose the metal substrate then use a hot trowel to spread the enamel into the damaged area. If the metal substrate is exposed then remove all loose coating. Where possible abrasively blast clean the exposed substrate and feather the blast cleaning onto the surrounding coating. If abrasive blast cleaning is not possible then use mechanical wire brushing. Apply a trowelling or brushing grade of a compatible, two pack liquid repair system and overlap onto the surrounding coating.

SUSTAINED LOADS

Description

Deformation of the coating due to compression and / or creep.

Cause

Incorrect use of pipe supports or padding during storage/construction, ie standing pipe directly onto timber battens without protective padding.

Comment

Control the sack height of pipes in the pipe storage dump and during transportation. Use padding to prevent point loads.

Remove all loose coating. Where possible abrasively blast clean the exposed substrate and feather the blast cleaning onto the surrounding coating. If abrasive blast cleaning is not possible then use mechanical wire brushing. Apply a trowelling or brushing grade of a two pack, liquid urethane and overlap onto the surrounding coating.

BLISTERING AT FIELD JOINTS

Description

Very poor adhesion of the coating to the pipe.

Cause

Poor surface preparation including abrasive blast cleaning profile and removal of contaminants. Gassing from cellulos ic welds may contribute to this problem.

Comment

Use correct procedures for surface preparation and removal of contamination. Do not attempt coating operations over cellulosic welds until sufficient time has been allowed for all of the hydrogen to be evolved.

Remove all loose coating. Prepare the exposed substrate by abrasive blast cleaning, roughen the surrounding coating and feather the edges. Remove all contamination. Apply a two pack, liquid urethane or epoxy repair material.

BLISTERS

Description

Raised areas of coating.

Cause

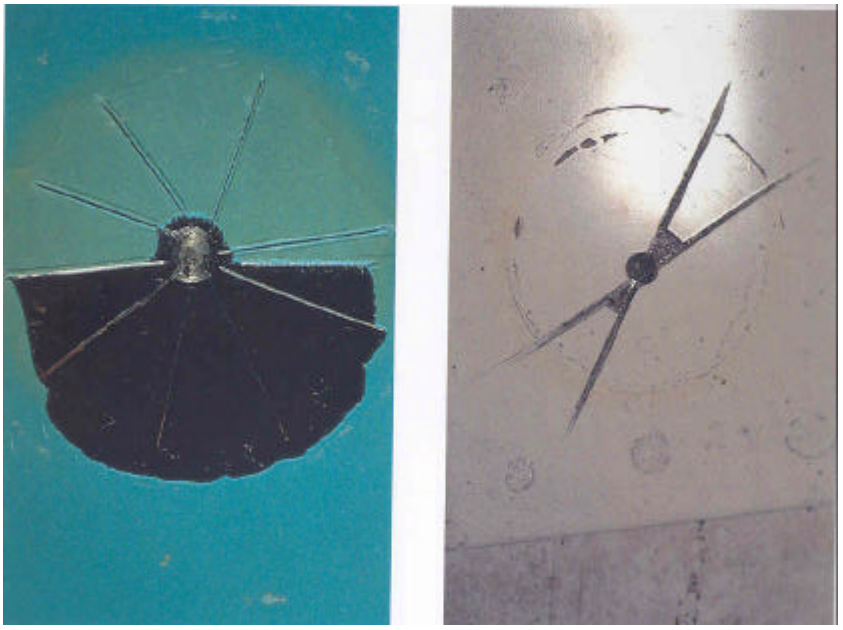
Blistering may occur over areas of contamination on the pipe surface or where there is a relatively high level of moisture within the coating or at the coating – steel interface. Blisters can appear in the coating plant but are most common during induction heating for field joint coating. Blisters may develop when coated pipe is reheated for any reason.

Comment

Improve surface preparation and coating practices in the mill and on site.

For isolated blisters remove all areas of coating with poor adhesion. Roughen the adjacent area of sound coating, remove all contamination and ensure the surface is dry. Apply a two pack, liquid repair material.
Where blistering is extensive the pipe should be re-coated.

CATHODIC DISBONDING



Description

Complete loss of adhesion at the coating – metal interface around an area of damage.

Cause

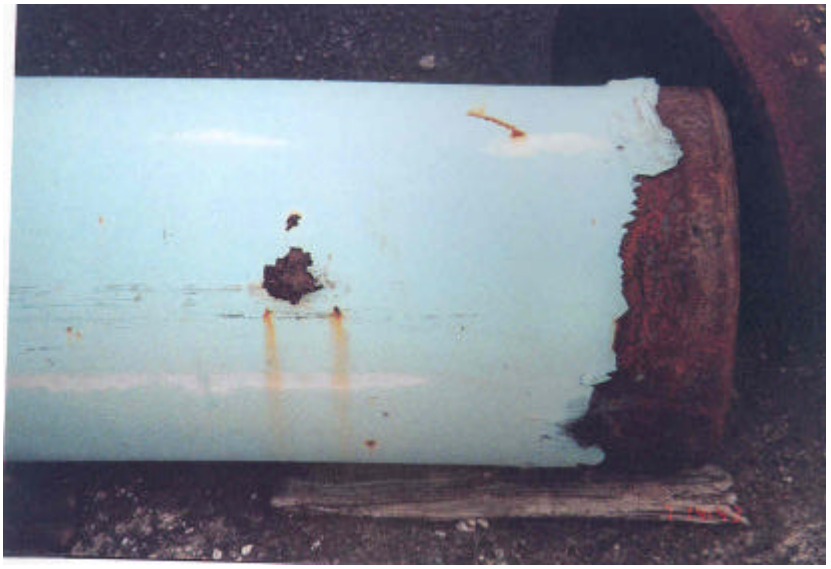
Loss of adhesion around a coating defect may be caused by moisture uptake or the reaction of the applied cathodic with the steel – coating interface.

Comment

The resistance of the coating to cathodic disbonding will be improve by a good last profile, a clean surface and chemical surface treatments such as phosphoric acid and chromate.

Remove all loosely adhering coating. Blast clean the substrate, if required, and remove all contamination and feather back onto sound coating. Apply a two-pack liquid urethane or epoxy repair material.

CORROSION AT CUT BACK



Description

Lifting of the coating at the ends of the pipe with corrosion underneath.

Cause

Moisture creep under the coating from the cut back or moisture ingress through defective coating. Incorrect temperature profile along the pipe in the coating mill resulting in ‘cold’ pipe ends and poor adhesion.

Comment

Ensure that the plant application parameters are correct. Resistance to adhesion loss will be improved by the use of chemical treatments such as phosphoric acid and chromate. Apply a temporary protective to the cut back on pipes that are expected to remain in storage for long periods. Remove all loose coating procedures or blast clean and feather onto sound coating, remove contamination and apply a two pack liquid urethane or epoxy repair material.

DOUBLE SHELL

Description

A discontinuity in the pipe wall that, in extreme cases, splits the pipe wall into two segments.

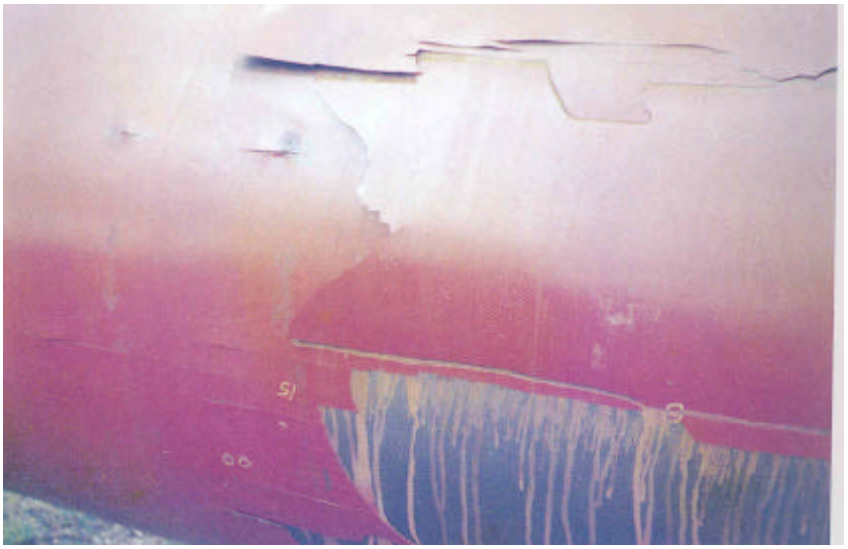
Cause

Commonly associated with an interrupted pour at the ingot stage which allows surface oxidation to occur within the partially formed ingot. The line of oxide remains as a zone of weakness in the finished ingot and separation occurs along the zone during forging.

Comment

Separations that run at an angle to the pipe wall may be structurally significant and should be detected by the inspection procedures in the pipe mill. Separations that rum parallel to the pipe surface may not be detected, but may not be significant.

CRACKS



Description

Thin lines that appear as a different colour to the main body of coating. After weathering rust staining may accentuate the line of the cracks.

Cause

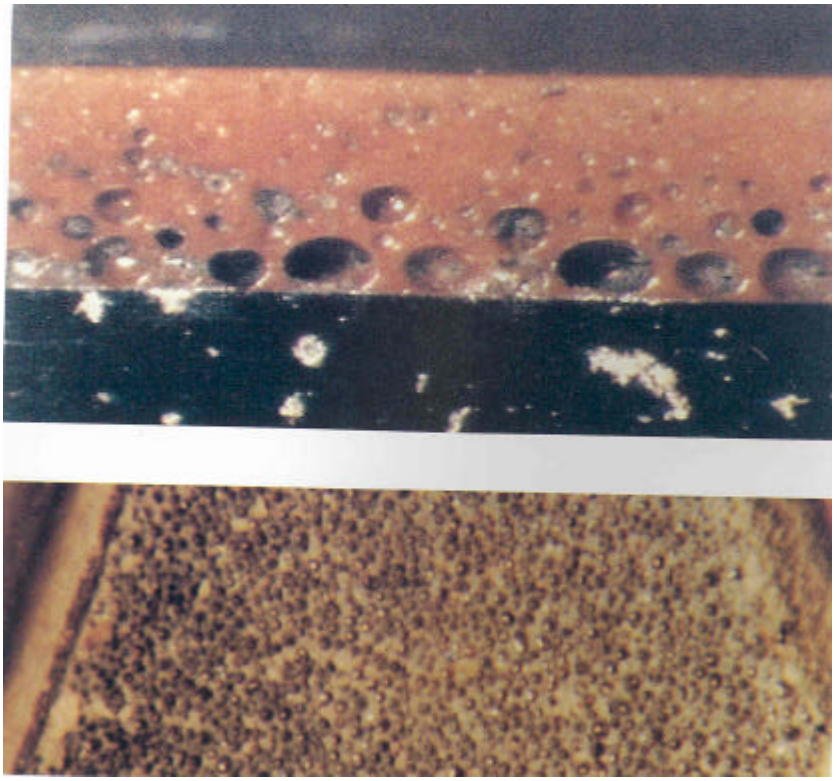
Cracking may occur during cold bending or hydrostatic testing and the risk of cracking is increased if these operations are carried out at low temperature and at high strain. The risk of cracking is increased by over-cure of the coating.

Comment

Establish a minimum temperature limit for cold bending and hydrostatic testing and limit the degree of strain to lie within the coating's demonstrated flexibility.

Either, encapsulate the cracks by roughening the affected area, with an overlap onto sound coating, and overcoat with a two pack, liquid urethane or epoxy repair material.
Or, remove all of the affected coating, blast clean and remove any contamination and feather onto sound coating. Apply a two pack, liquid epoxy or urethane repair material.

FOAMING



Description

Round, gas filled voids within the coating. The void content is usually highest close to the metal surface.

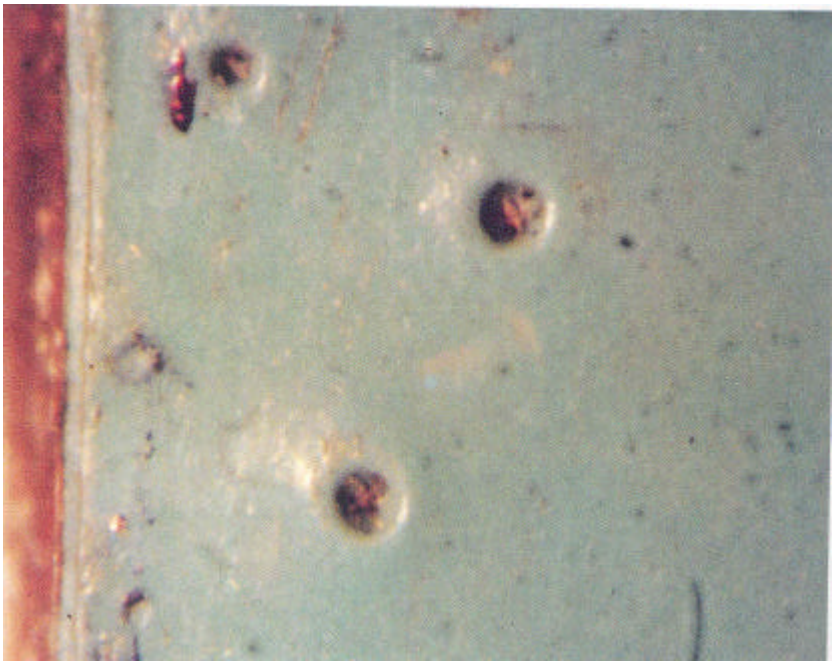
Cause

Application temperature too high or moisture content of the powder is too high.

Comment

Ensure that the moisture content of the powder complies with the manufacturers recommendations.
Ensure that the substrate temperature is within the correct range for powder application.
In the coating plant: Strip the pipe and recoat.
On site: Strip the affected area and re-coat using field joint coating procedures or overwrap with heat shrink wrap around sleeves of the ‘three layer’ type using a two pack liquid primer.

INCLUSION



Description

Bumps and protrusions on the surface of the coating.

Cause

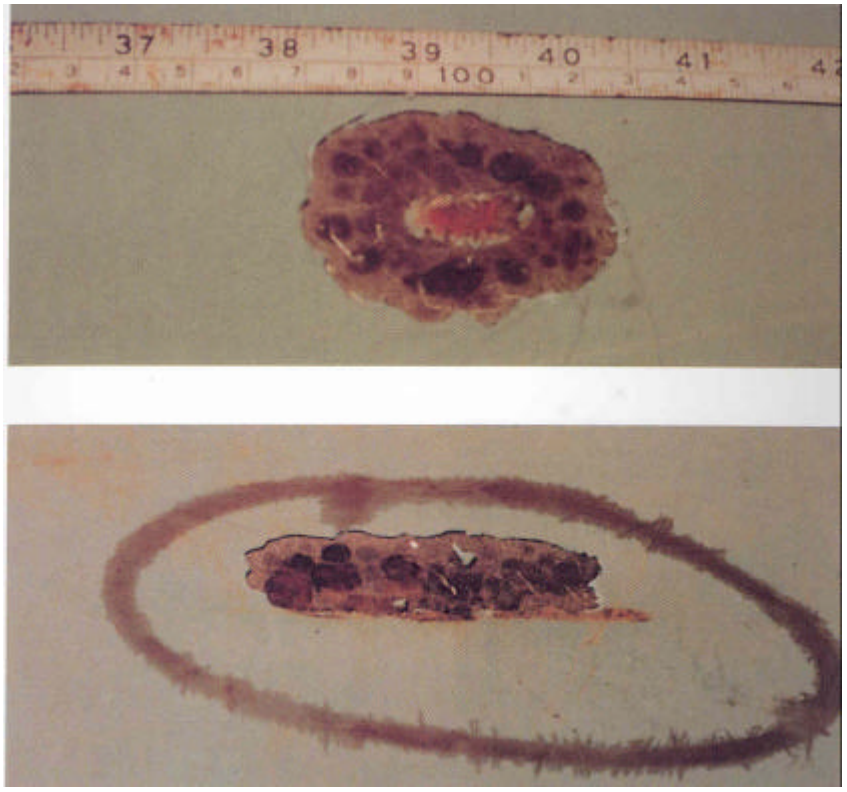
Material trapped in the coating as it gels and cures including impacted powder, rubber, metal slivers, dirt, agglomerated powder or other small particulates that may be present in the coating plant or on site during field joint coating operations.

Comment

Ensure cleanliness of the coating application plant and control the proportion of recycled to virgin powder.

Remove all affected coating and abrade the area of damage with an overlap onto sound coating. Remove all contamination. Apply a two pack, liquid urethane or epoxy repair material

LEOPARD SPOTTING



Description

Rust spotting beneath delaminated or disbonded coating around pinholes in the coating.

Cause

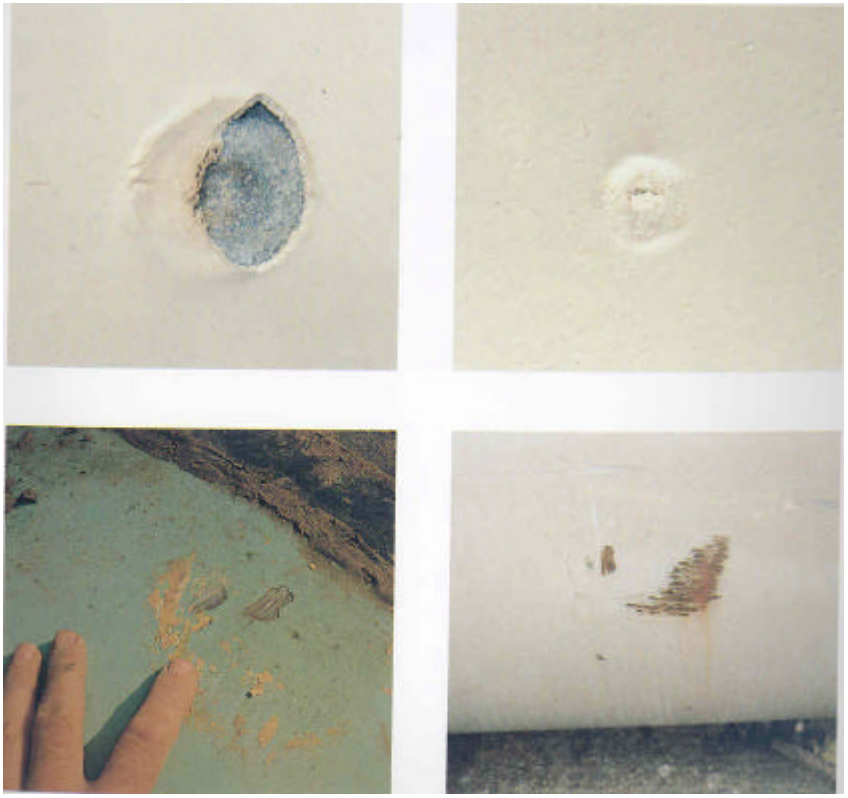
Incomplete removal of salt contamination during surface preperation which creates small corrosion cells as moisture penetrates to the steel surface.

Comment

Modification to the coating process to include washing to remove soluble salts and possibly to include chemical pre-treatments such as phosphoric acid or chromate.

Remove all loose coating and abrade the area of damage with an overlap onto sound coating. Remove all contamination. Apply a two pack, liquid urethane or epoxy repair material.

MECHANICAL DAMAGE



Description

Irregular shaped areas where the coating has been lost.

Cause

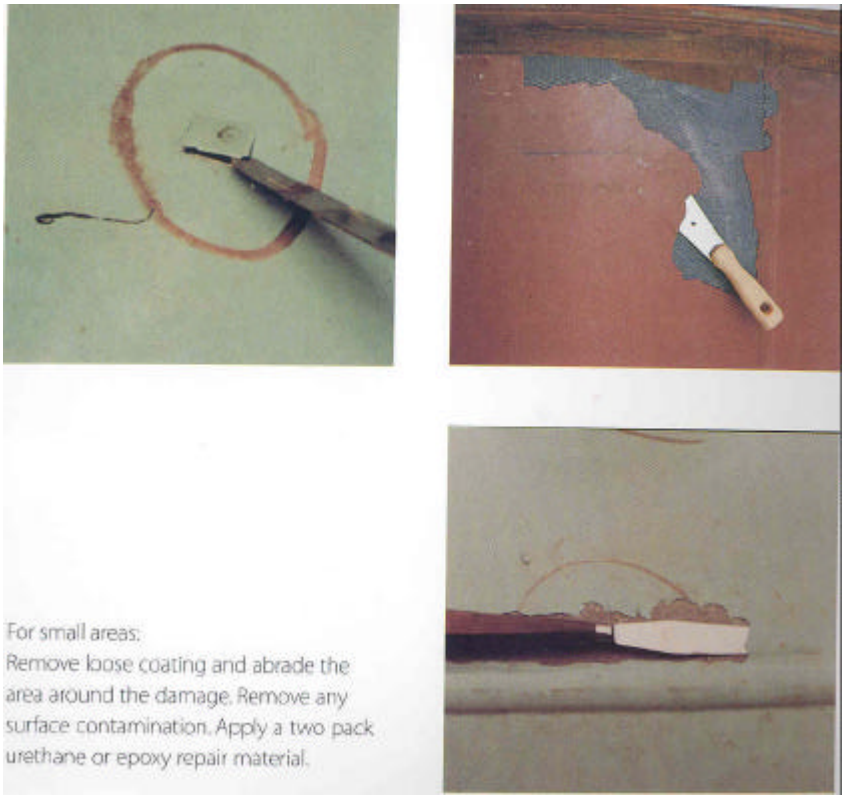
Impacts from excavation or construction equipment or from pipe bevels during handling.
Stone damage due to vandalism or impacts from rocks in the backfill may also occur.

Comment

Observe correct handling and backfilling procedures.

Remove all loose coating and abrade the area of damage with an overlap onto sound coating.
Remove all contamination. Apply a two pack, liquid urethane or epoxy repair material.

POOR ADHESION



Description

Coating has lost all adhesion, or can be easily peeled from the substrate.

Cause

A number of factors may contribute to this problem, including: incorrect surface profile; shielding of the pipe surface from blast abrasive cleaning by the linear seam weld bead; contamination of the surface; incorrect application temperature; inadequate flow of the fused coating into the blast profile.

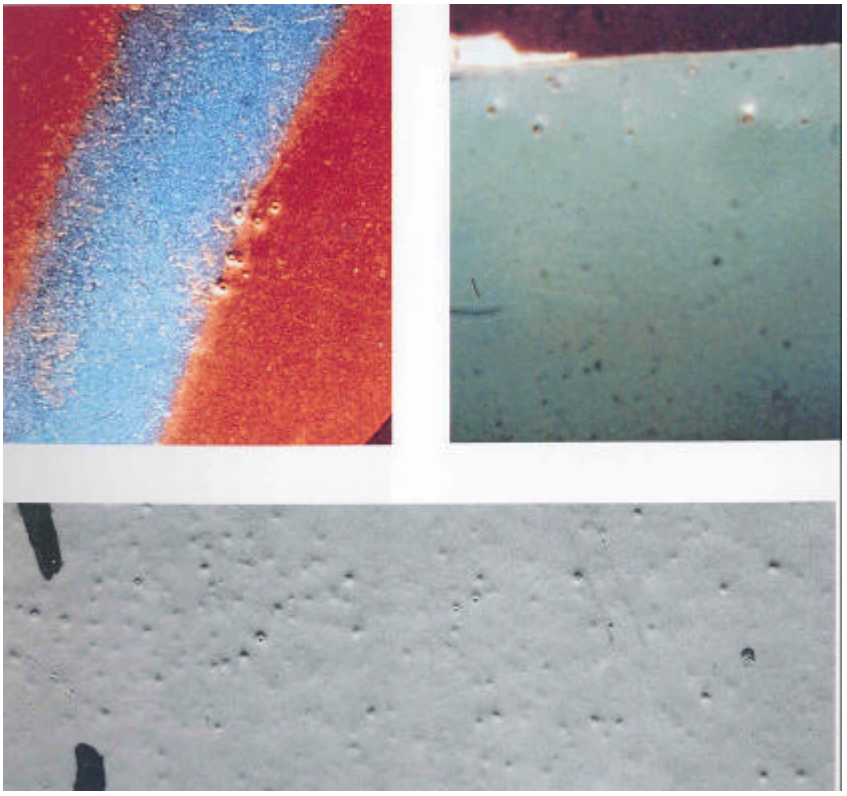
Comment

The resistance of the coating to loss of adhesion will be improved by a good blast profile, a clean surface and chemical surface treatments such as phosphoric acid and chromate.

For large areas:
Remove loose coating and apply the procedures approved for the coating of field joints.

For small areas:
Remove loose coating and abrade the area around the damage. Remove any surface contamination. Apply a two pack, urethane or epoxy repair material.

ROUGHNESS/PINHOLES



Description

Broken blisters showing at the coating surface. On badly affected pipe this may appear as general roughness on the surface of the coating.

Cause

Inadequate surface preparation. Blistering may be caused by soluble salts or corrosion products remaining on the pipe surface after surface preparation for coating application. Moisture contained in the contamination is driven off during the heating and coating process. This moisture generates bubbles in the coating which appear on the surface as raised ‘eruptions’ and pinholes.

Comment

Upgrade the surface preparation procedures to remove contamination, for example by the use of phosphoric acid treatment. Remove the affected coating, prepare the surface and apply a two pack liquid urethane or epoxy.

WELD SPATTER

Description

Irregular holidays in the coating adjacent to girth welds.

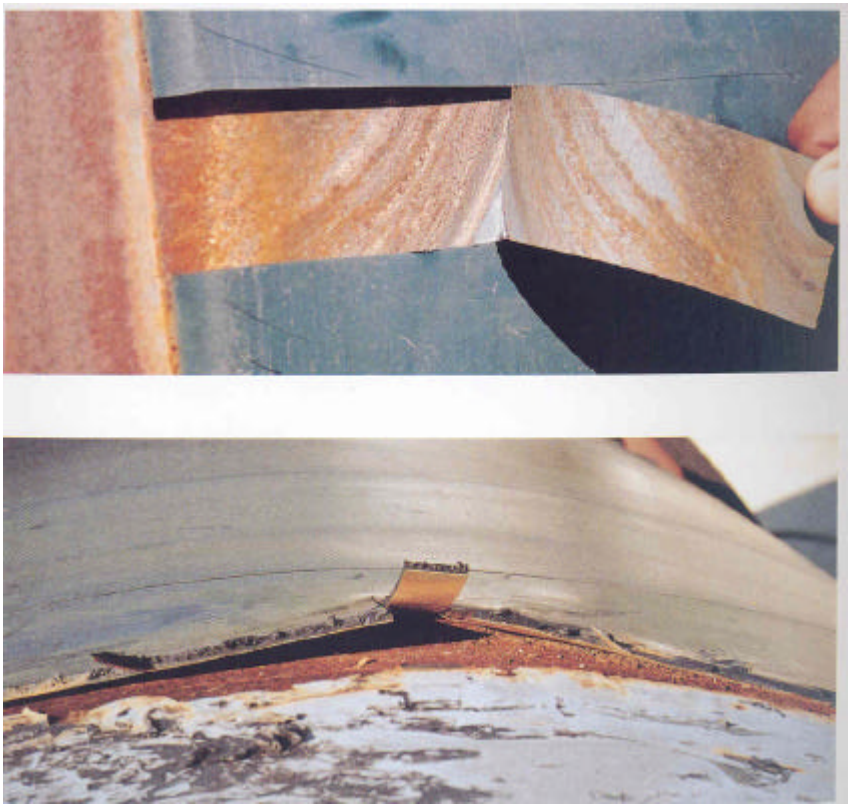
Cause

Damage caused during girth welding. Weld spatter causes localized defects by burning through the fusion bonded epoxy powder coating.

Comment

Protect the pipeline coating from weld spatter adjacent to the cut back area at the end of the pipe.

ADHESION LOSS AT CUT BACK



Description

Complete loss of adhesion, during storage, of the coating next to the cutback at the bevel ends of pipe or fittings. Corrosion may be present beneath the affected coating .

Cause

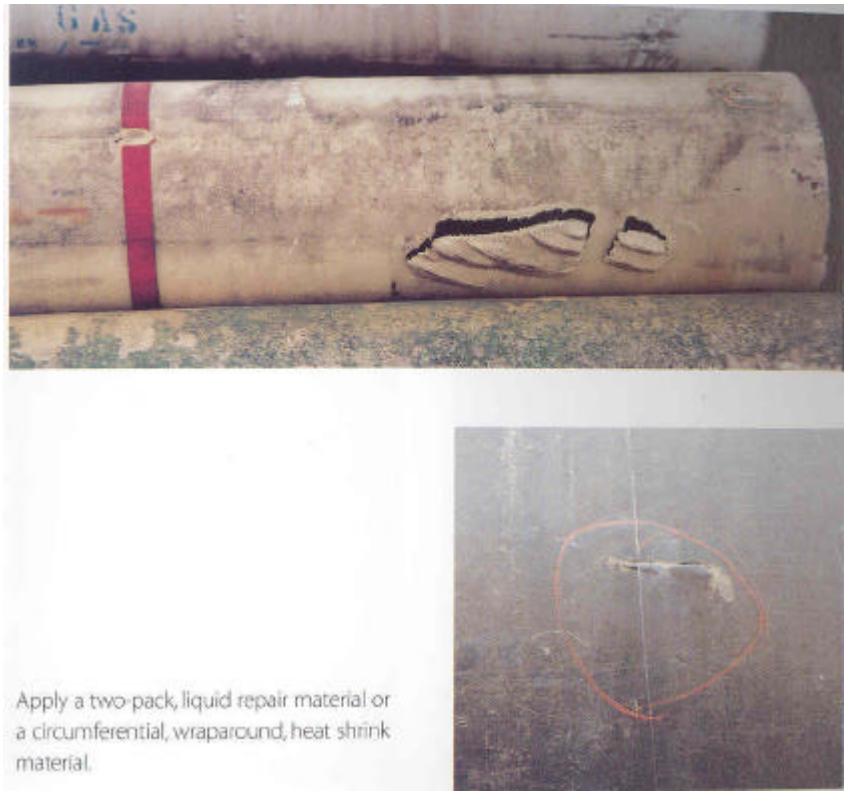
Moisture creep under the coating during storage. This process will be accelerated by contamination under the coating and poor original adhesion due to incorrect application.

Comment

Ensure correct procedures are used for surface preparation and coating application.

Cut back the affected areas to sound coating. This creates a larger cut back than normal at pipe joints. Prepare and coat the enlarged cut back using the normal field joint coating procedures.

MECHANICAL DAMAGE



Description

Irregular shaped tears or damage to the coating that exposes the pipe surface or allows water to penetrate to the pipe surface.

Cause

Damage from excavation or construction equipment, or from impacts from pipe bevels during handling.

Damage may also result from point loads during storage, for example placing pipe directly onto wooden battens, and from stone or rock impact in the pipe bed or backfill.

Comment

Observe appropriate storage, handling and ditching procedures.

Remove all of the loose coating. Chamfer the edges of the sound coating and clean and prepare the damaged area including an overlap onto sound coating.

Apply a two-pack, liquid repair material or a circumferential, wraparound, heat shrink material.

INGOT DEFECTS

Description

Irregular shaped crack-like defects running into the pipe wall at a high angle to the pipe surface.

Cause

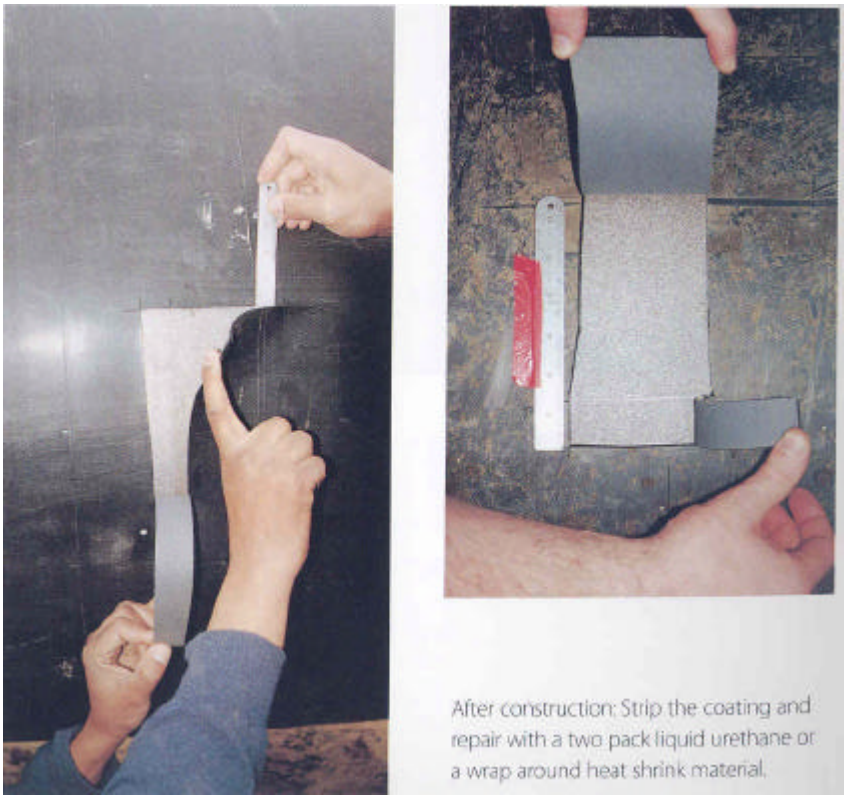
Defects in the surface of the original ingot that have not been removed duri ng scarfing in the pipe forming process.

Comment

Small surface defects are not structurally significant but may create defects in thin film coatings.

Superficial defects may be removed by grinding before application of the coating.

POOR ADHESION



After construction: Strip the coating and repair with a two pack liquid urethane or a wrap around heat shrink material.

Description

Loss of bond to the substrate such that all layers of the coating may be removed cleanly from the metal substrate.

Cause

A number of factors may contribute to this problem, including: contamination of the pipe surface, incorrect surface preparation, poor blast profile, incorrect pipe temperature for the application of the fusion bonded epoxy powder base layer.

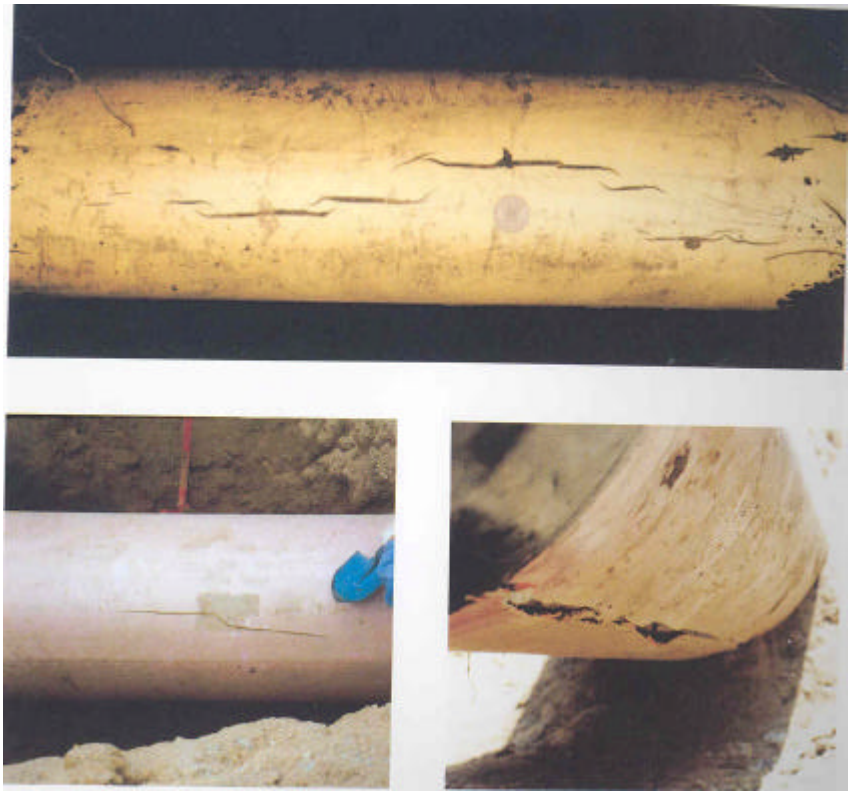
Comment

Remove all contamination from the substrate, including salts and oil. Check the blast profile on the substrate. Avoid contamination of the substrate after blast cleaning. Incorporate a phosphoric acid and chromate treatment into the coating procedure.

Before construction: Strip the coating completely and re-coat the pipe.

After construction: Strip the coating and repair with a two pack liquid urethane or a wrap around heat shrink material.

STRESS CRACKING



Description

Irregular cracks penetrating through the polyolefin layer. Cracks are predominantly longitudinal on pipes with a diameter larger than 150 mm, and may be circumferential on small diameter pipe.

Cause

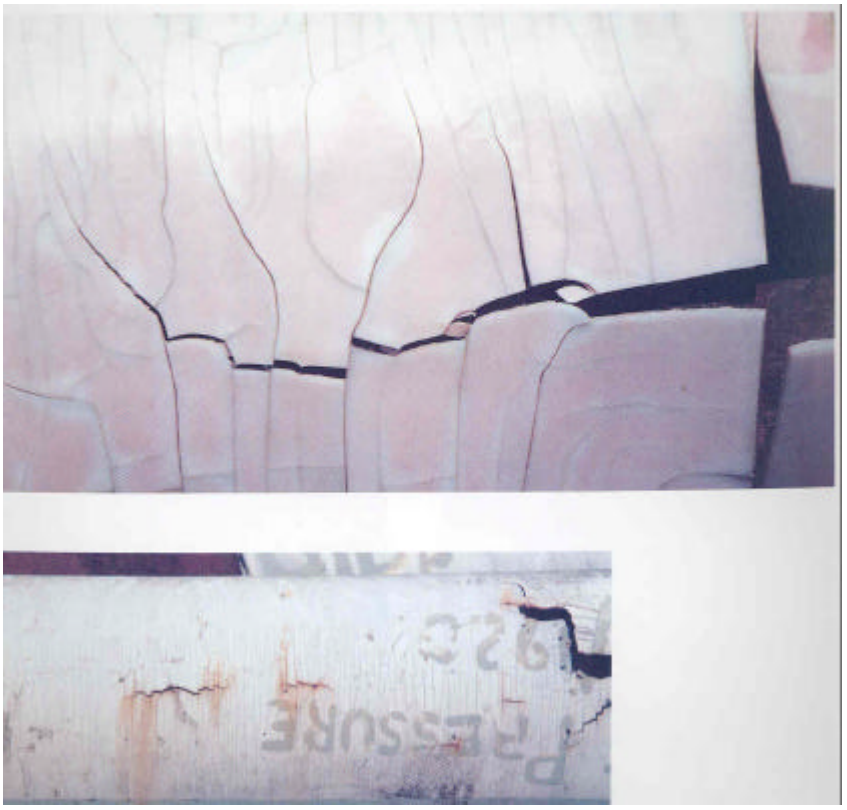
A combination of poor stress crack resistance in the polyethylene polymer and residual stress within the coating from the cooling phase of the coating application process.

Comment

Use only polyolefin polymers with good stress crack resistance.

Remove all loose coating. If possible blast clean the exposed steel and clean and roughen the coating around the exposed steel. Apply a compatible two-pack, liquid repair system or a circumferential heat shrink repair.

UV DEGRADATION



Description

Crazing and cracking of the polyethylene.

Cause

UV degradation and embrittlement of a susceptible polyolefin polymer during prolonged storage or in service above ground.

Comment

Use polyolefin polymers with good stress crack resistance.
Use carbon black filler to minimize Ultra Violet penetration.
Protect the coating from Ultra Violet exposure.

Strip the degraded coating from the pipe. Re-prepare the pipe surface and re-coat.

DELAMINATION

Description

Loss of adhesion between one layer of coating and the next.

Cause

Contamination between layers. Full cure attained on the first layer before the second layer was applied.

Comment

Make sure there is no contamination between layers.
Ensure that the manufacturers recommendations are followed for the timing of over-coating.

If the delaminated area can be removed prepare the substrate by abrasive blast cleaning and apply another layer of coating.

Otherwise completely remover all layers of coating and re-coat in the approved manner.

MIS METERING

Description

Mis-metering is characterized by blisters in the coating and soft areas of incomplete cure.

Cause

Incorrect mixing ratio, for example due to a pump metering problem. Incomplete mixing of the two components, most usually during hand mixing.

Comment

By hand: For pre-measured quantities ensure that all material, from part A and B, are used and that the two components are mixed until homogeneous. By pump: Ensure that pumps, meters ant the mixing head are functioning correctly.

Cut out affected areas back to sound coating. Chamfer the edge of the coating and prepare the surface. Apply a compatible two pack, liquid repair material.

POOR ADHESION

Description

Coating may be removed from the substrate.

Cause

Metal substrate contaminated or not prepared correctly, for example the surface profile may not be rough enough.

The ‘pot life’ of the material was exceeded before application.

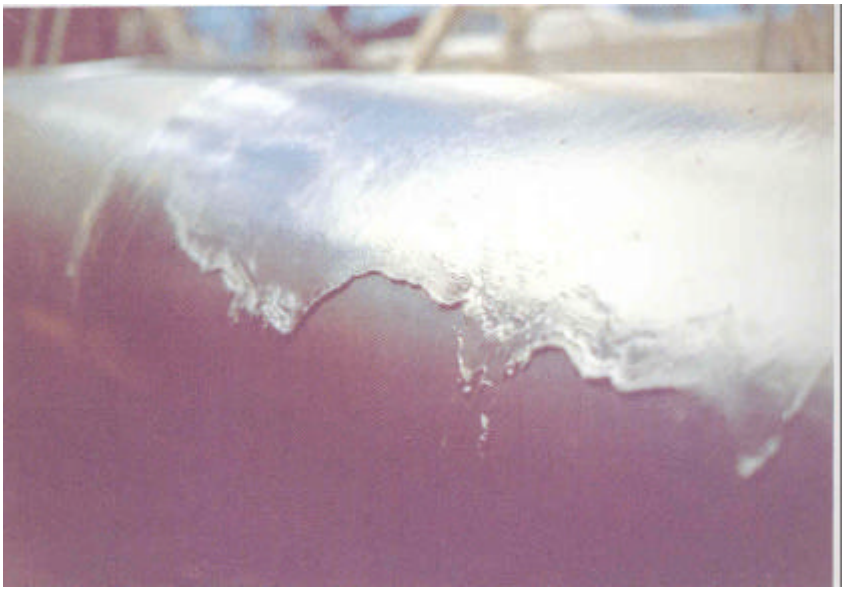
The coating may not have flowed into the depressions in the profile or was applied when the ambient temperature was too high.

Comment

Observe good application practice and procedures.

Completely remove the affected coating. Re-prepare the substrate and re-coat.

SAGGING



Description

Runs and sags visible on the coating surface.

Cause

Incorrect metering or application of coating in layers that too thick. Poor application technique.

Comment

Runs and sags are unsightly but if the coating shows correct adhesion and cure the protection performance may be unimpaired.

ADHESION LOSS AT OVERLAP

Description

Spiral pattern of corrosion following the line of overlap between successive turns of tape.

Cause

Poor application procedures giving insufficient overlap between successive turns of tape. The problem may be aggravated by soil stressing or loading.

Comment

Specify the minimum acceptable overlap between successive turns of tape, for example 55 %. Carry out coating procedure qualification tests and operate an effective quality control policy an site. Remove all of the cold applied laminate tape and prepare the substrate and coating on either side. Apply a compatible two pack, liquid urethane coating or re-wrap with cold applied laminate tape ensuring a minimum overlap of at least 55 % between turns.

LOSS OF ADHESION

Description

Tape becomes detached from pipe surface and water enters behind the coating. Where soil is washed in the coating may sag under the weight.

Cause

Loss of adhesion which may be aggravated by soil loading.

Comment

Good site inspection and quality control procedures should reduce the risk of adhesion loss.

Affected coating should be removed and the pipe surface prepared for re-coating. A two pack liquid urethane coating should prevent repetition of the problem. Where tape has to be used for re-coating a double wrap system is advisable.

MECHANICAL DAMAGE

Description

Tearing of lifting of the coating in areas where it has been subject to an impact load.

Cause

Impingement of the coating by mechanical plant, machinery or pipe bevels during handling and stringing.

Comment

Improve handling and safety procedures.

Remove all loose coating.

For small areas of damage use an overwrap of cold applied laminate tape, ensuring a minimum of three complete turns around the pipe and an overlap of 55% between turns.

For large areas of damage prepare the exposed metal substrate and the adjacent coating and apply a compatible two pack, liquid coating or rewrap with cold applied laminate tape ensuring a 55% overlap between successive turns of tape.

LAMINATONS

Description

A discontinuity lying parallel to the pipe surface, usually marked by a concentration of non-metallics.

Cause

Rolling-out of inclusions, blow holes, pipes or ingot cracks in the parent material.

Comment

Large laminations may be structurally significant. Some older pipelines contain pipes with large laminations that have not created a safety hazard in many years service. However, such defects could pose a problem if through-thickness stresses are generated in the pipe wall, for example during top tap or repair welding operations.

Surface breaking laminations may contribute to coating faults and may serve as an initiation point for pitting corrosion.

SOIL CREEP

Description

Coating is wrinkled and may be displaced longitudinally along the pipe axis.

Cause

Soil creep occurs on slopes and this movement will be at a maximum after backfilling as the fill settles and compacts. The nett movement is downslope, under the action of gravity. Coating damage will be greatest where the pipeline route follows the line of maximum slope. Only coatings that are susceptible to creep will be affected.

Comment

Use coatings that are not susceptible to creep.

Overwrap the primary corrosion protection coatings with an adherent, low friction coating.

Overwrap with a loose, deformable protective layer, but this layer MUST NOT interfere with cathodic protection current access to the pipe.

Strip all areas of coating that show loss of adhesion or voids and all areas with moisture beneath the coating. Re-coat with a compatible repair material, such as a two pack , liquid urethane.

SOIL LOADING

Description

Loosening, cracking and tearing of the coating with associated loss of adhesion. Linear wrinkles parallel to the pipe axis, usually at 3 o'clock and 9 o'clock. The wrinkles may be filled with water.

Cause

After construction the backfill consolidates and this generates a tensile load on the coating results. The effect is most marked on large diameter pipe.

Comment

Cold applied laminate tape, a plasticised coating, is very susceptible to soil loading. Over-wrap with an adherent, low friction coating to reduce the problem. The exposed ends of cold applied laminate tape must be left pointing downwards. All the damaged coating must be removed and the metal substrate and surrounding sound coating must be cleaned. Re-coat using a compatible two-pack, liquid coating, heat shrink materials or cold applied laminate tape.

SOIL STRESSING

Description

Loosening and lifting of the tape, with associated loss of adhesion, particularly at the edges of the tape and at the end of the ‘wrap’.

Cause

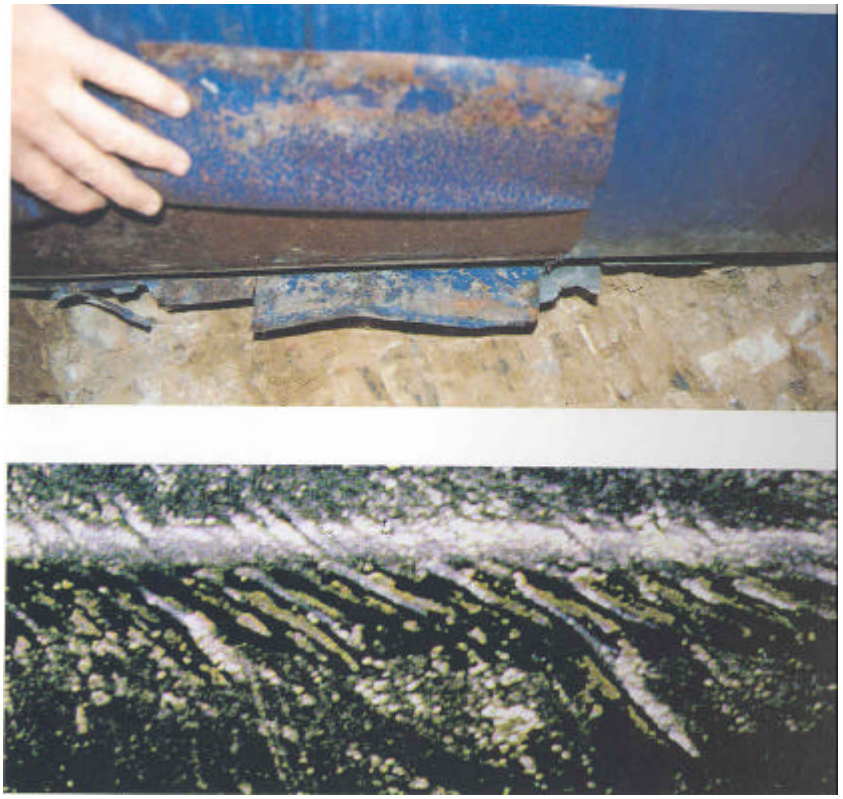
Heavy clay soils can expand on wetting and contract on drying. This expansion and contraction can be transferred from the clay to the coating resulting in loosening, lifting and loss of adhesion.

Comment

Cold applied laminate tape, a plasticised coating, is very susceptible to soil loading. Over-wrap with an adherent, low friction coating to reduce the problem. The exposed ends of cold applied laminate tape must be left pointing downwards.

All the damaged coating must be removed and the metal substrate and surrounding sound coating must be cleaned. Re-coat using a compatible two-pack, liquid coating, heat shrink materials or cold applied laminate tape.

TENTING OR BRIDGING AT SEAM WELD



Description

Air or water filled voids beneath cold applied laminate tape on either side of the seam or spiral weld bead.

Cause

The tape is tensioned over the weld bead during application to leave a void.

Comment

1. Profile either side of the weld bead with mastic before applying the tape.
2. Place a longitudinal strip of tape over the weld bead and the adjacent pipe before applying the main tape coating.
3. All the damaged coating must be removed and the metal substrate and surrounding sound coating must be cleaned. Re-coat using a compatible two-pack, liquid coating, heat shrink materials or cold applied laminate tape.

POOR APPLICATION

Description

Poor adhesion, or complete loss of adhesion, usually at the 6 o'clock position.

Cause

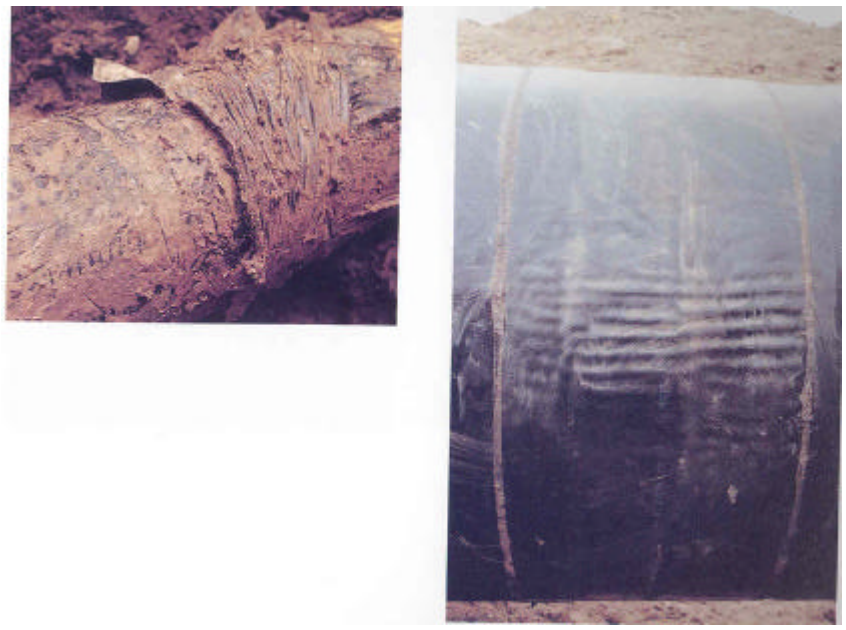
Poor application technique and insufficient heating around the bottom of the pipe.

Comment

Good application technique supported by coating procedure qualification testing and effective, on site, quality control.

Strip the coating and re-coat with cold applied laminate tape, where the backfill conditions are good, or apply a new heat shrink wrap-around. Alternatively a two pack liquid coating may be applied provided it is compatible with the coating on the pipe body.

SOIL LOADING



Description

Wrinkling of the heat shrink material at the 3 o'clock and 9 o'clock positions in response to soil settlement. Axial wrinkling may result from soil creep on slopes.

Cause

Settlement of the backfill, after construction, generates a tensile load in the coating. On slopes the settlement may include an element of soil creep, downslope, and this may include stresses in the coating aligned with the pipe axis.

Comment

Use coatings that are not susceptible to creep.

Over-wrap the heat shrink material with an adherent, low friction coating.

Over-wrap with a loose, deformable protective layer which MUST NOT interfere with cathodic protection current access to the pipe.
Completely remove the coating. Prepare the joint area and apply a compatible two pack. Liquid material with an overlap onto the coating on the body of the pipe.

GROUND BED

Description

Horizontal ground bed used in conjunction with a power supply. The Silicon-Iron anodes are placed in a low resistivity, coke breeze backfill to maximize current output.

Comment

The ground bed should be located 100-200m from the pipeline to minimise problems of over protection at the drain point and to ensure uniform current distribution over a long length of pipeline. Ground beds must not be located close to other pipelines or framed structures to avoid electrical interference and stray current corrosion. Where space is limited, for example on a compressor station, a vertical ground bed may be used. The anodes are installed in a borehole at depth to give good current distribution on the complex site pipework.

INSULATION JOINT

Description

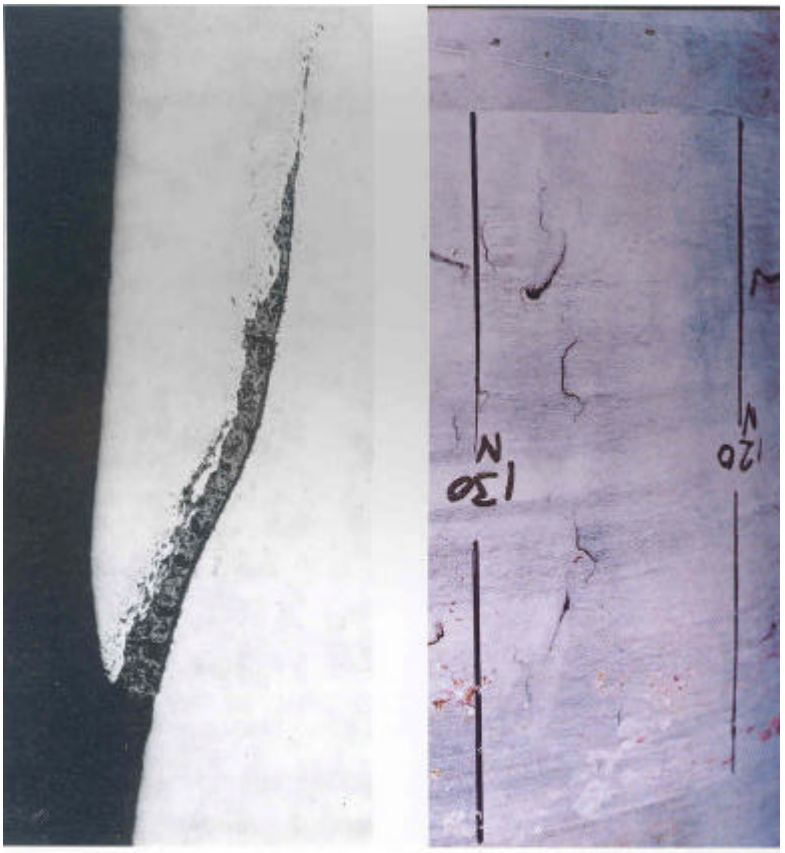
A prefabricated insulation joint or a flange assembled using insulating gaskets sleeves and washers.

Comment

Insulation joints are essential to provide electrical insulation between adjacent pipeline sections and between a pipeline and plant installations such as block valves and compressor or pumping stations.

Pipework at a plant site may be shorted to reinforcing bars in concrete or other structural steelwork through pipe supports, control lines etc. Contacts of this kind create problems with the successful application of cathodic protection.

LONGITUDINAL SURFACE LAPS



Description

A flap of metal lying flat on the pipe surface, usually with a trapped residue of oxide or scale beneath it.

Cause

A metal protrusion that is folded and deformed into the hot metal surface during the pipe-forming process.

Comment

Generally small laps have little or no structural significance. Laps to create holidays, or defects, in thin film coatings. Soluble salts trapped in the scale or oxides beneath the lap may act as a corrosion ‘hot spot’ and initiate pitting.

Superficial surface laps may be removed by grinding before application of the coating.

SACRIFICIAL ANODE

Description

Zinc or Magnesium alloy sacrificial anode packaged in a low resistance Bentonite fill.

Comment

Sacrificial anodes are of particular value for small cathodic protection in congested areas where the low current output avoids interference problems.

Zinc anodes may be ineffectual in soils contaminated with industrial waste, such as coke. Magnesium anodes are required for effective cathodic protection in these conditions.

TEST POINT

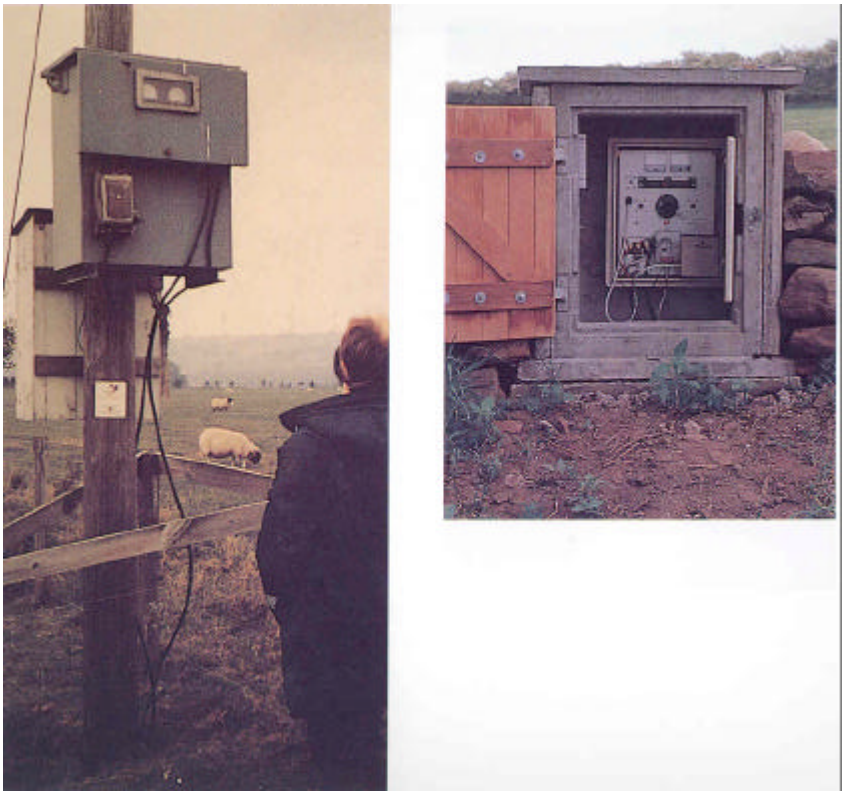
Description

A cable connection to a buried pipe, that terminates at a test post or box on the surface. The surface connection measurements to be made.

Comment

Accurate pipe to rail potential measurements are needed to maintain the effectiveness of the cathodic protection applied to a pipeline. Routine monitoring may be carried out at test posts only by recording accurate instant of potential of a test coupon buried at a test post. A periodic close interval potential survey, between test posts may also be required to fully audit the effectiveness of a cathodic protection scheme.

TRANSFORMER RECTIFIER



Description

Mains or solar powered power supplies for large cathodic protection schemes on cross-country pipelines and plant sites.

Comment

The current output is adjustable to provide fine control of the protection field.

COATING AND SOIL

Interaction

Thermoplastic coatings are susceptible to creep under sustained loads, for example from the soil. Defects generated by sustained soil loads can be found in hot enamel coatings, cold applied tapes and heat shrink materials.

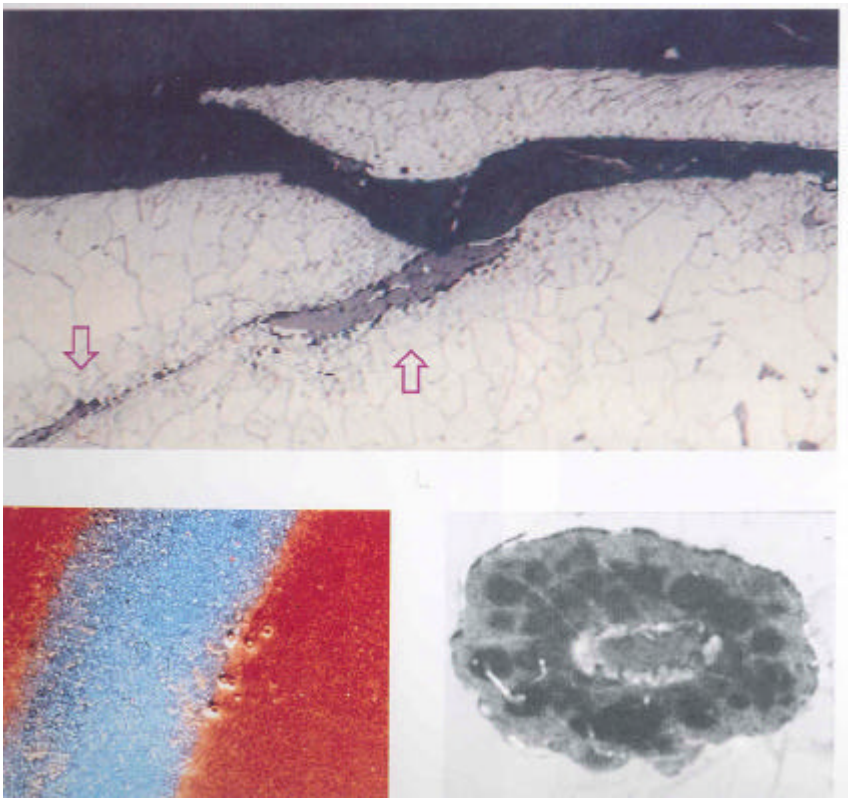
The commonest symptoms include cracking, wrinkling, coating displacement and penetration.

Defects are typically located as follows:

- Cracking on the crown of the pipe
- Wrinkling on the ‘sides’ of the pipe
- Stone penetration on the bottom of the pipe, particularly where the pipe bed is uneven
- Coating displacement in the downslope direction

Random disruption is expected in expansive clays.

PIPE SURFACE PREPARATION



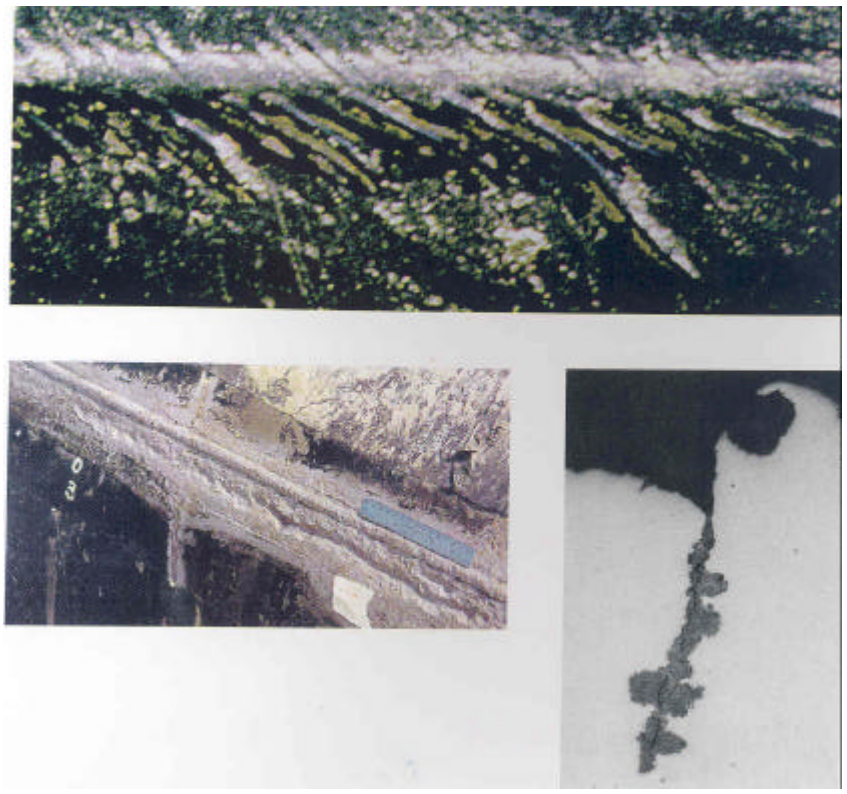
Interaction

Trapped slag exposed at the pipe surface act as a reservoir for moisture and for salts accumulated during transport of pipe by sea and storage on a dockside.

During the application of thin film, fusion bonded epoxy powder coatings, steam and gas may escape from the slag to create small defects or bubbles in the coating.

Residual salt acts as a catalyst for corrosion and loss of adhesion with characteristic rust spotting, ‘leopard spots’, where salt remains on the pipe surface.

TAPE – NAEC - SCC



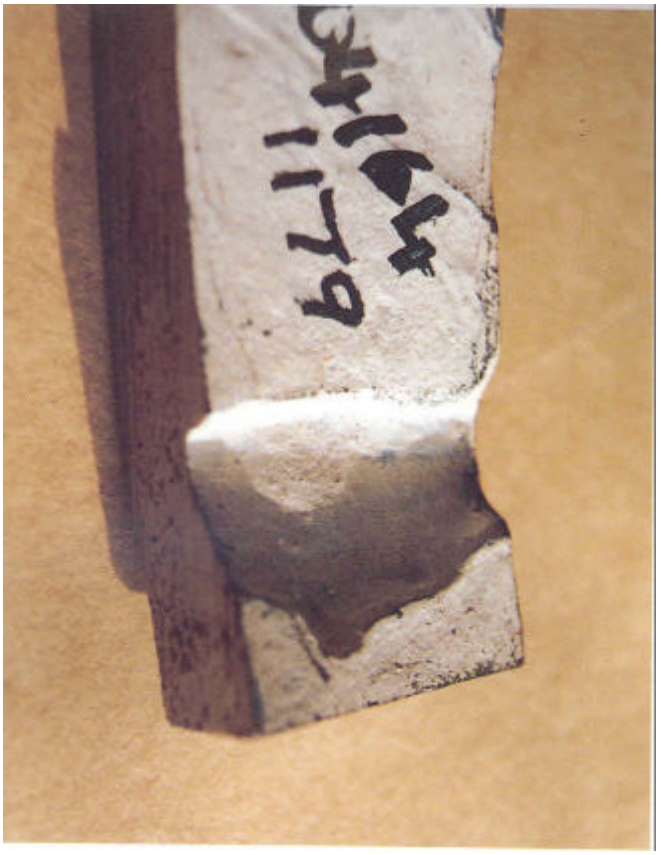
Interaction

Bridging of cold applied tape over the cap of the seam weld leaves a void on either side of the weld line. When water gets into this void a corrosion risk is created. The applied cathodic protection current cannot control this corrosion risk because the pipe is shielded from the CP current by the insulating coating.

On spiral welded pipe this results in a pattern of corrosion that follows the spiral weld.

Near neutral pH stress corrosion crack growth may also occur but the total axial length of interconnected cracks will be restricted.

MANUFACTURING DEFECTS



Description

Irregular shaped defects in the pipe wall.

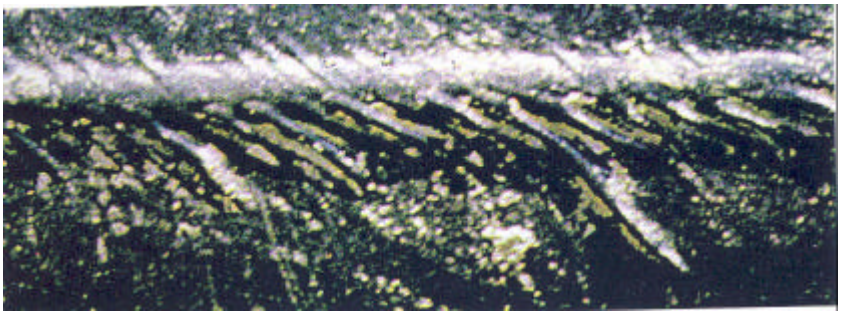
Cause

Solidification defects in the ingot that are carried through into the pipe or pieces of lapped material that have fallen out.

Comment

Significant manufacturing defects should be identified b pressure testing in the pipe mill or during the pre-commissioning pressure test.

TAPE AND SPIRAL WELD



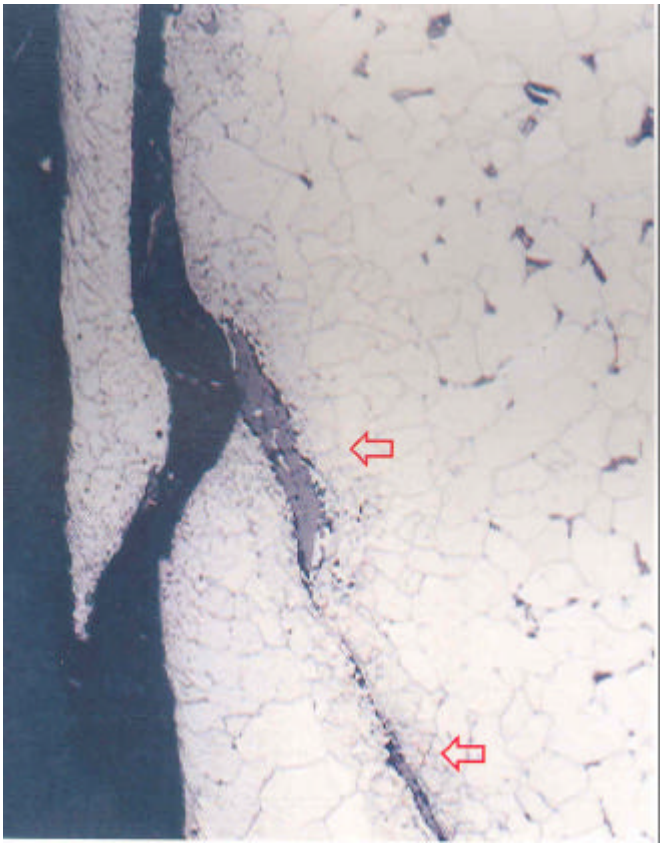
Interaction

Bridging of cold applied tape over the cap of the seam weld leaves a void on either side of the weld line. When water gets into this void a corrosion risk is created. The applied cathodic protection current cannot control this corrosion risk because the pipe is shielded from the CP current by the insulating coating.

Lines of 'narrow axial' corrosion result. These areas of corrosion may also be susceptible to the initiation and growth of near neutral pH stress corrosion cracks.

See also:
Cold Applied Tape – Bridging
External Corrosion – NAEC
External Corrosion – Near Neutral pH SCC

SLAG INCLUSION



Description

Non-metallic inclusion in the pipe wall.

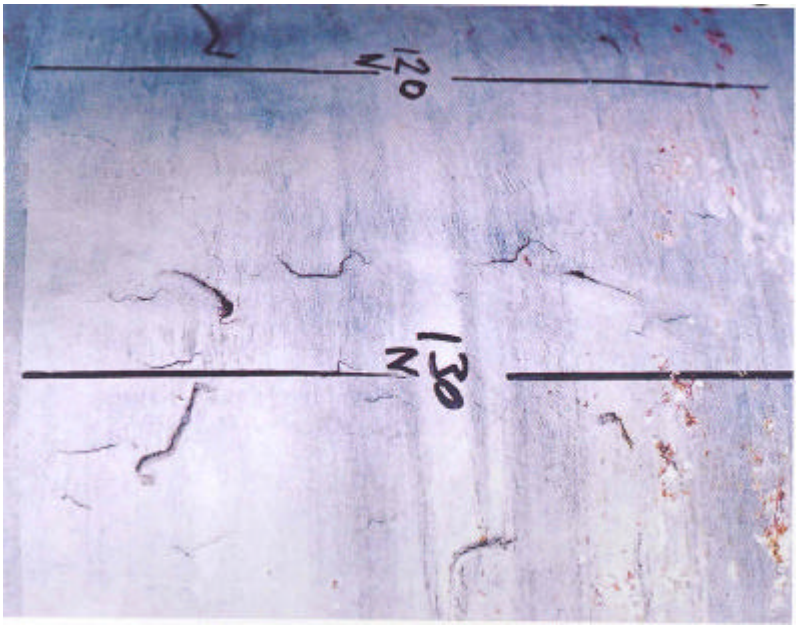
Cause

Caused when an ingot is contaminated with slag. In well controlled pipe production most slag inclusions are removed during the piercing process and when the ends of the ingot are trimmed during the pipe forming process. The shape of the slag inclusion will be governed by the forging process.

Comment

Slag inclusions are usually too small to be structurally significant. However, surface breaking slag may initiate a corrosion ‘hot spot’ or a defect in a thin film pipe coating. Superficial slag inclusions may be removed by grinding before application of the coating.

SURFACE DEFECTS



Description

Shallow defects that appear at the pipe surface.

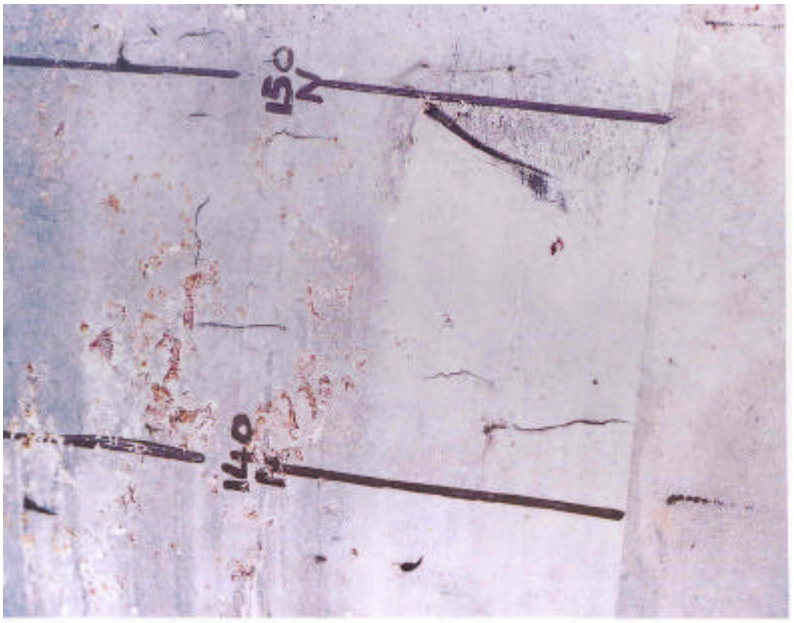
Cause

Various causes including ingot defects, longitudinal surface laps, slag inclusions, slivers, transverse tears and surface roughness.

Comment

Most defects are not structurally significant but may create defects in thin film coatings and act as an initiation point for pitting corrosion.

TRANSVERSE TEARS



Description

Crack like features at the pipe surface running in the hoop direction.

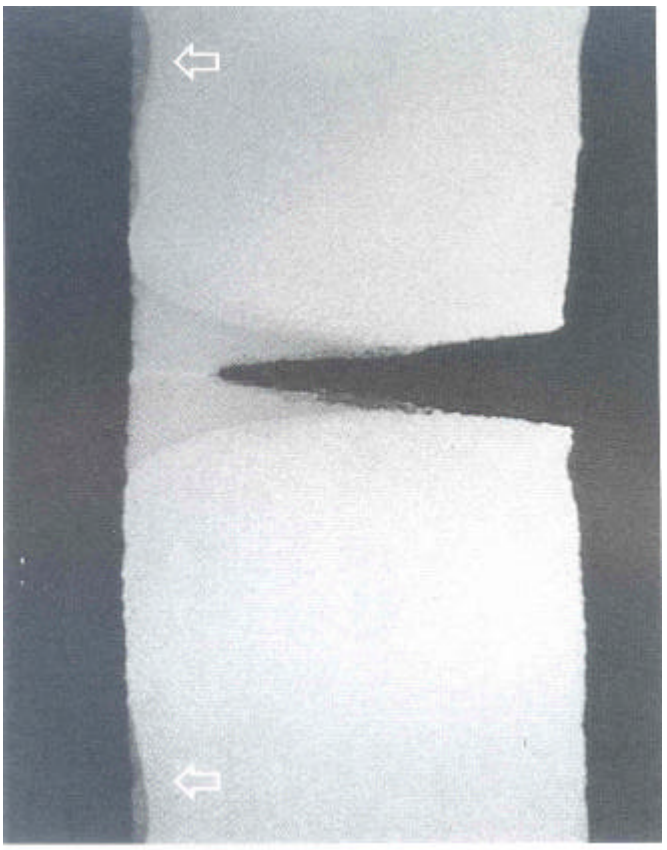
Cause

Cracks in the ingot, for example transverse shrinkage cracks, may be carried through to the pipe if insufficient material is removed from the ingot surface during the scarfing process.

Comment

Transverse tears may create defects in thin film coatings. Superficial transverse tears may be removed by grinding before application of the coating.

BURN MARKS



Description

Local area of transformed, hardened, microstructure. It occurs on either side of the seam weld on the outer surface of the pipe. Burn marks may be associated with lack of fusion in the seam weld.

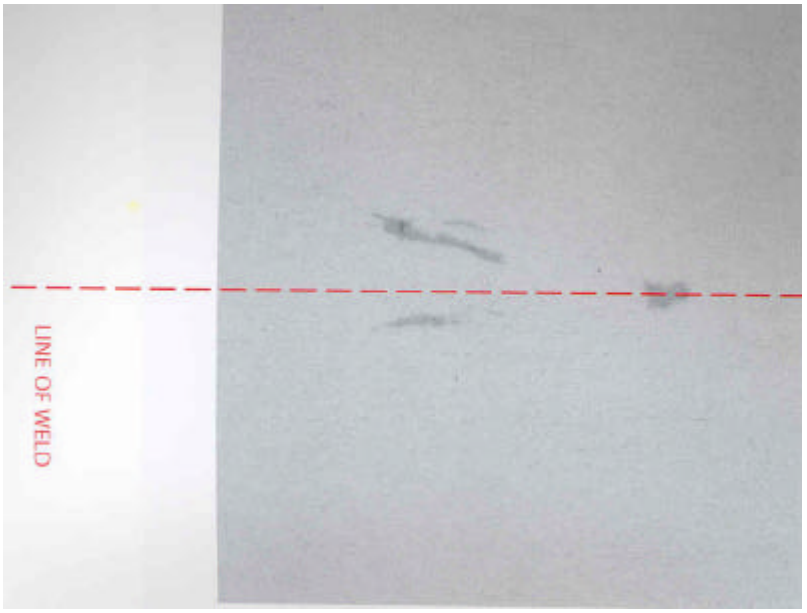
Cause

Poor or intermittent electrical contact between the rollers used to introduce the electrical current to the pipe. The rollers are located either side of the joint line on the outer surface of the pipe. Burn marks are not found on High Frequency Induction welded pipe.

Comment

Good maintenance and operation of the pipemaking equipment in the mill Repair is not usually required unless the burn marks are extensive when local dressing of the pipe wall, within acceptable grinding limits, and subsequent NDT inspection to confirm freedom from cracking should be carried out.

DIVERTED INCLUSIONS



Description

Aligned, non-metallic inclusions in the parent strip are diverted through 90 degrees at the weld seam causing a plane of weakness.

Cause

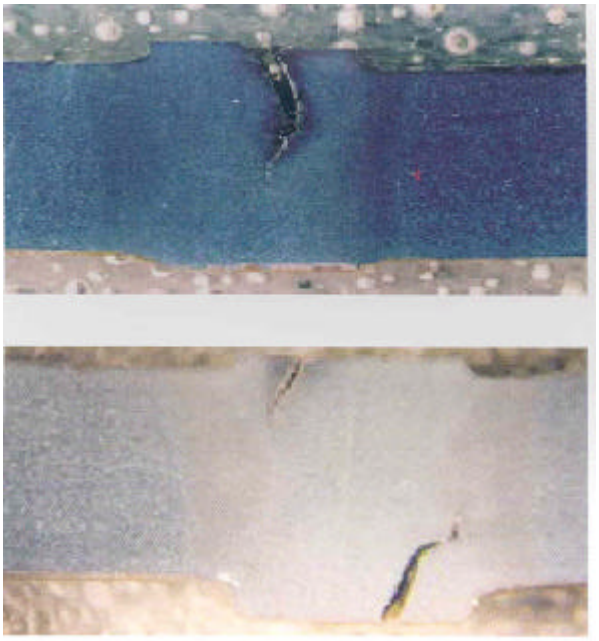
Poor quality, dirty, parent strip. The inclusions become realigned as a consequence of the welding process.

Comment

Use good quality, clean, strip.

Repair is not usually required unless the plane of weakness has resulted in a fracture through the pipe wall. When repair is required, replace the pipe or install a repair camp.

HOOK CRACKS



Description

Internal or external cracks within the weld, usually curved in shape. The cracks are axial and at right angles to the pipe surface.

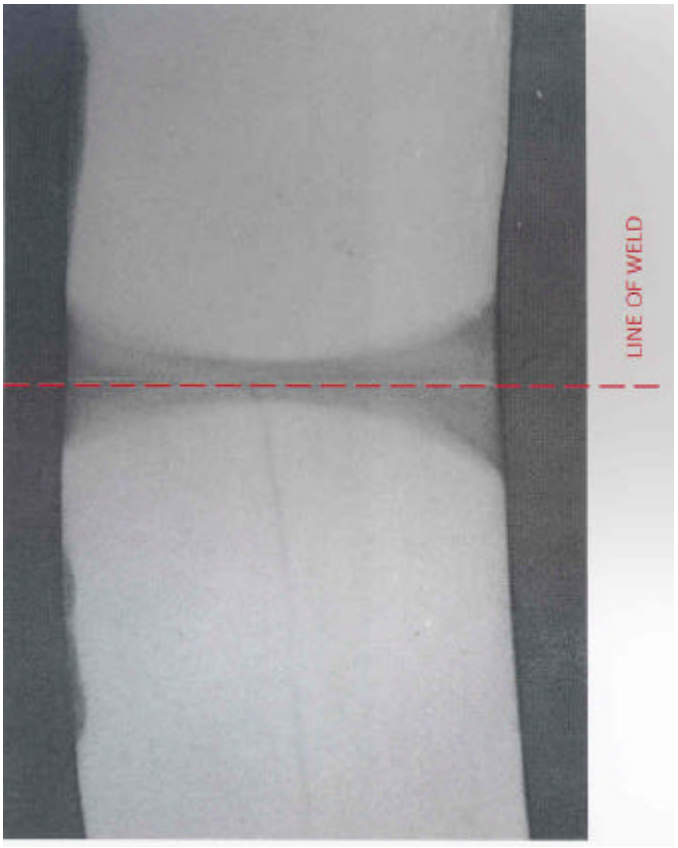
Cause

Poor quality, dirty strip.

Comment

Use good quality, clean strip. Replace pipe or install repair clamps or repair shells as appropriate.

MISSED NORMALISING



Description

Lack of grain refined structure at the weld line, leading to poor weld line toughness. Visible on the macro-section as the well defined heat affected zone on either side of the line of the weld.

Cause

Misalignment of pipe mill induction heat treatment coil so that on-line post weld treatment misses the weld zone.

Comment

Ensure correct set up of the weld line tracking equipment in the pipe mill.

Missed normalizing can lead to failure along the weld line by brittle fracture when the pipeline is subject to severe service conditions. This problem is only detected by pipeline failure so replacement is necessary.

SEAM MISPLACED TRIM

Description

Axial groove or depression aligned to one side of the seam weld.

Cause

Misalignment of the weld trim grinding tool with the result that grinding is offset from the centre line of the weld.

Comment

Ensure correct set-up, maintenance and operation of the equipment in the pipe mill.

Misplaced trim is unlikely to contribute to pipe failure, except in the most extreme operating conditions, so repair is not normally required.

SEAM OVERTRIM

Description

Axial groove or depression on the line of the seam weld.

Cause

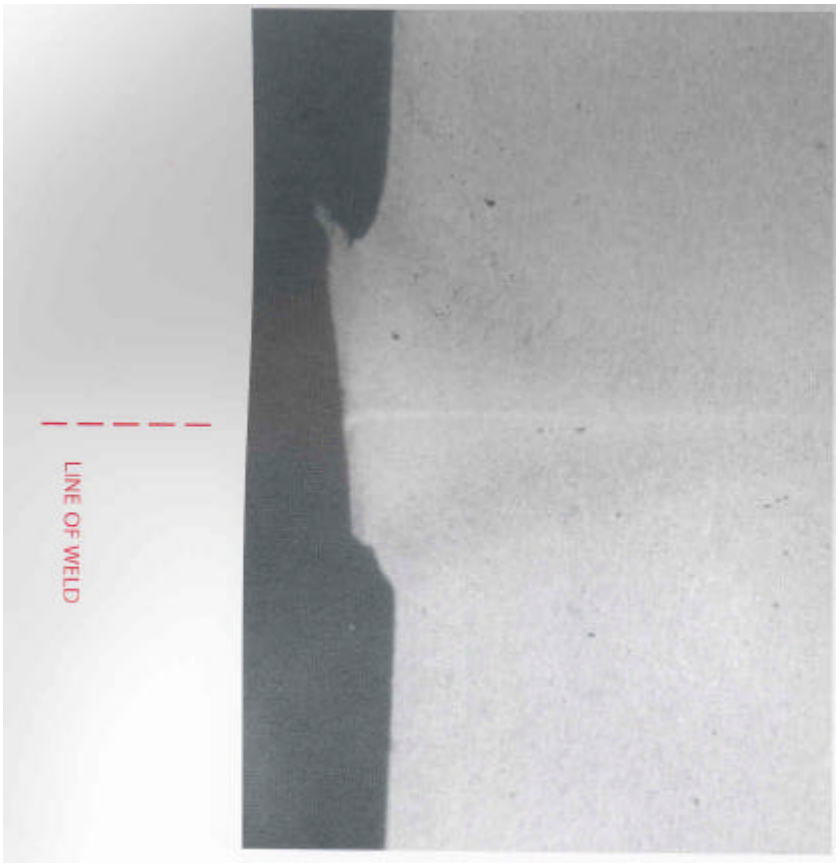
Excess grinding of the weld flash.

Comment

Ensure correct maintenance, set-up and operation of the pipe making equipment in the mill.

Overtrim is unlikely to contribute to pipe failure except in the most extreme operating conditions. Repair is not normally necessary.

SEAM UNDERTRIM



Description

Linear feature standing proud of the pipe surface on the line of the seam weld.

Cause

Insufficient grinding of the weld flash.

Comment

Ensure correct set-up, maintenance and operation of the equipment in the pipe mill.

Undertrim is unlikely to contribute to pipe failure, except in the most extreme operating conditions, so repair is not normally required.

CONCAVE CAP

Description

Concave profile in the weld cap.

Cause

Insufficient weld metal caused by a travel speed that is too fast or by two few weld runs. Concave cap is most common at the 3 o'clock and 9 o'clock positions on the pipe.

Comment

Use a slow travel speed. Add a 'stripper' run to the 3 o'clock and 9 o'clock positions before capping in order to build up the thickness locally.

Not a significant defect if the total weld thickness is greater than the pipe wall thickness.

COPPER CRACKING

Description

Cracking in the weld metal, normally close to the weld centre line. Cracks follow the weld solidification structure.

Cause

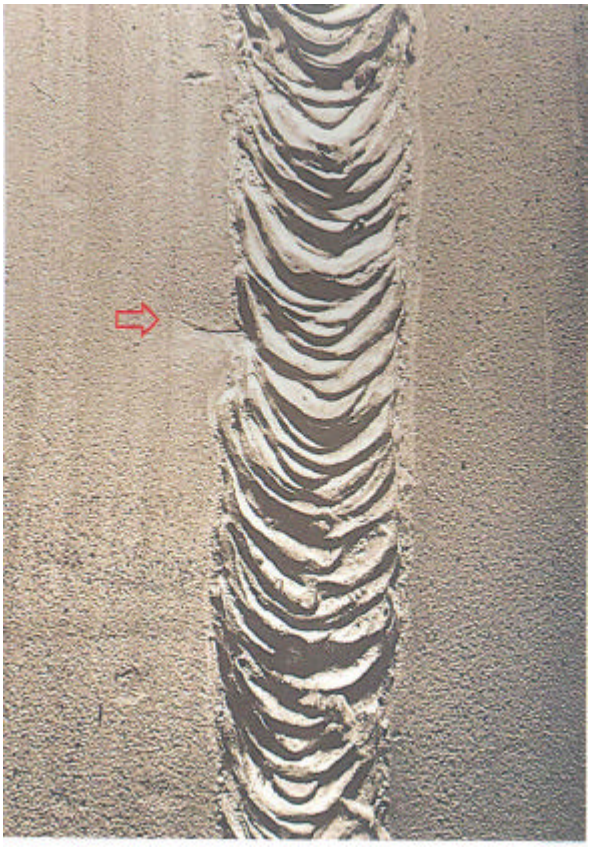
Accidental introduction of copper into the weld pool either from build up of copper dust from filler wire coating or from melting of electrode contact tube.

Comment

Ensure correct maintenance and operation of the seam weld equipment in the pipe mill.

Cut out affected pipe and replace.

END CRACK



Description

Axial crack located at the end of the pipe.

Cause

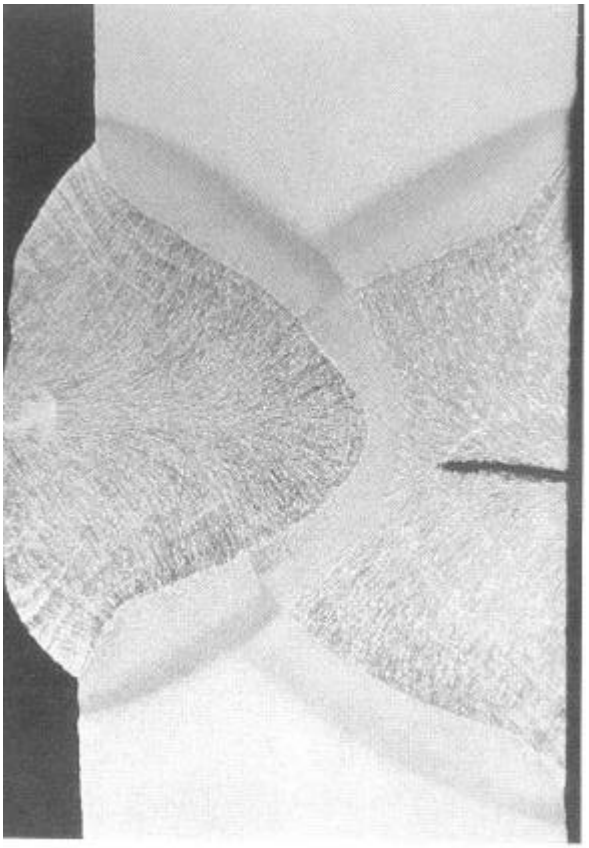
End cracks are usually small, < 10mm long. They are caused by the stress induced in the pipe when the end plugs are forced into the pipe during the mill hydrostatic test.

Comment

End cracks may not be identified in the hydrostatic test carried out in the pipe mill because the leak rate is too small to be detected at this stage of construction. Leak rates may be too low to detect in the pre-commissioning hydrostatic pressure test.

Cracks found during construction must be cut out and the pipe re-welded.

END CRACK



Description

Solidification crack in the centre line of the weld bead. Tends to occur towards the end of a pipe in the last metal to solidify.

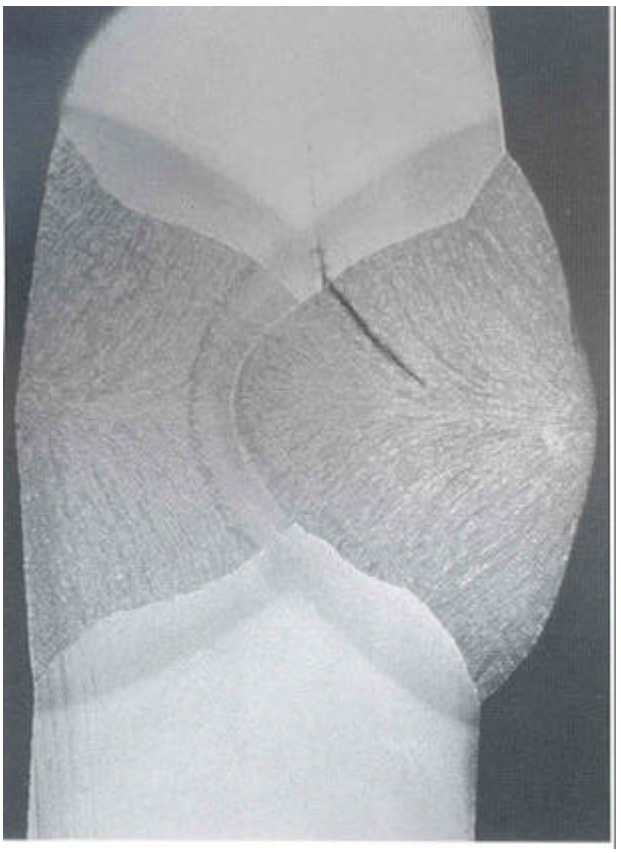
Cause

Low melting point impurities in the weld metal, possibly diluted from dirty parent plate. Poor solidification profile in the weld, for example a high bead depth to width ratio. Stress on the weld during solidification.

Comment

Ensure correct welding procedures and welding conditions in the pipe mill. Cut out the pipe section and replace.

HOT TEAR AT LAMINATION



Description

Solidification crack in the weld bead that has initiated from a band of segregation in the parent plate.

Cause

Plane of weakness and high chemistry material at segregated band in the plate initiates a crack in the adjacent weld bead during weld pool solidification.

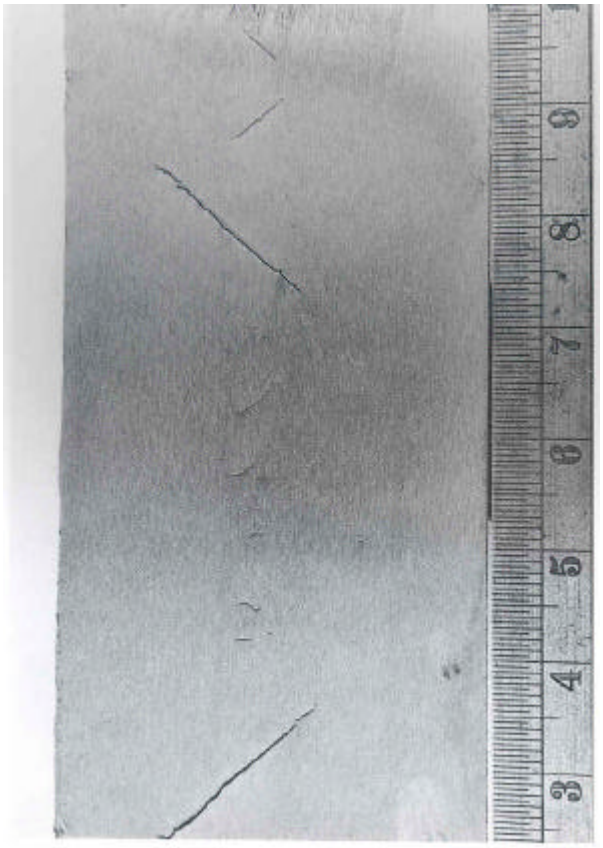
Comment

Use clean plate.

May only be discovered if the pipe sees severe service.

Cut out and replace the affected pipe. Alternative repair procedures may be acceptable subject to a full defect assessment.

HYDROGEN CRACKING



Description

Transverse cracks in weld bead often lying on alternate 45° planes. Also referred to as ‘chevron’ cracking.

Cause

Damp flux, high strength consumables.

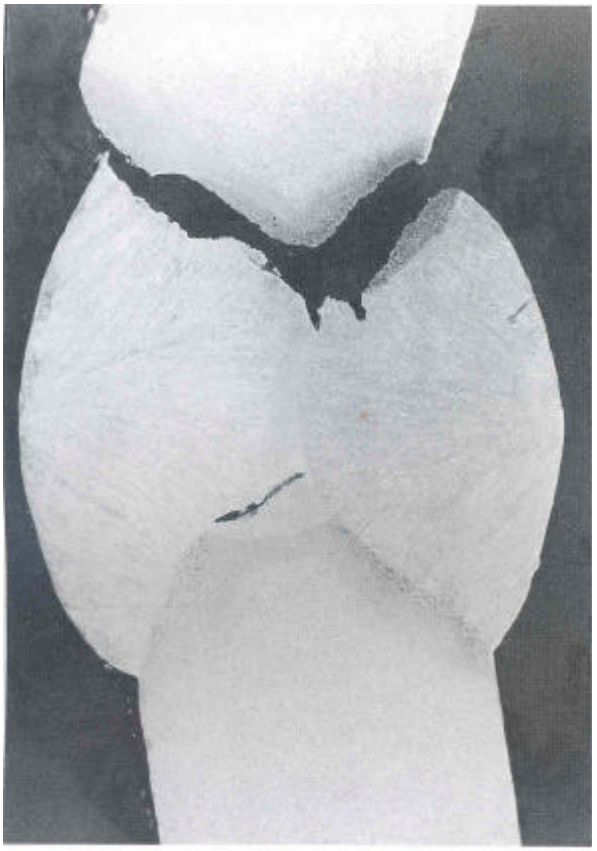
Comment

Only found in thick wall (>25mm) and high strength (> API 5 L X60) pipe. Prevented by correct consumable storage and handling.

May only cause problems in severe service conditions.

Cut out and replace the affected pipe. Alternative repair procedures may be acceptable subject to a full defect assessment.

LACK OF FUSION



Description

Linear defect at weld sidewall, or in top edge of the weld.

Cause

Incorrect positioning of welding head or incorrect welding parameters resulting in lack of fusion.

Comment

Ensure weld line tracking equipment is functioning correctly.
Ensure correct welding procedures are used.

May cause failure during cold expansion in the pipe mill otherwise it may only be discovered if the pipe sees severe service conditions.

Cut out and replace the affected pipe. Alternative repair procedures may be acceptable subject to a full defect assessment.

LACK OF INTER PENETRATION

Description

Linear defect between the inside and outside weld beads. The crack like defect is aligned through the wall thickness.

Cause

Root face too large or welding conditions incorrect.

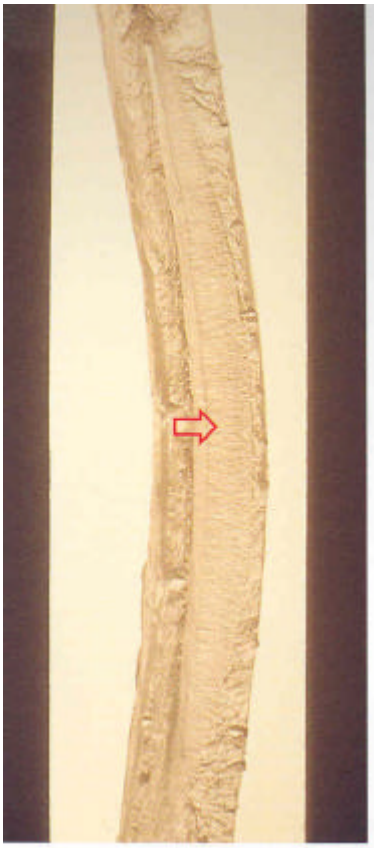
Comment

Ensure accurate machining of the root face and correct choice of welding conditions.

Look for sufficient interpenetration of the external and internal weld beads on macro-sections taken during the Manufacturers Procedure Qualification Test. Check also during routine Quality Control testing.

May only be discovered if the pipe sees service.

MISALIGNMENT



Description

Lack of fusion in the seam weld.

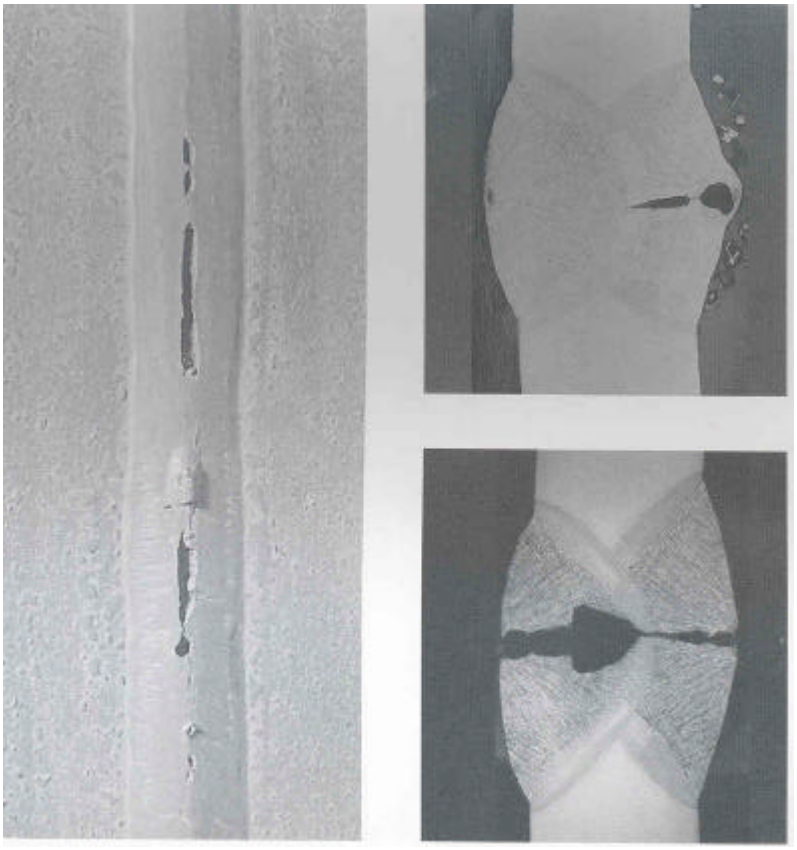
Cause

Misalignment of the weld bead resulting in lack of fusion at some point in the weld profile.

Comment

Misalignment can produce large defects in the seam weld which should be detected in the mill test or pre-commissioning hydrostatic test. Testing below 105% of the specified minimum yield strength (SMYS) may not reveal all defects.

POROSITY



Description

Void in the weld metal which can be isolated, clustered or in the form of piping.

Cause

Damp flux or loss of flux cover.

Comment

Ensure correct use and storage of welding consumables.

May only be discovered if the pipe sees severe conditions.

ROOF TOPPING

Description

Peaking at the SAW seam weld.

Cause

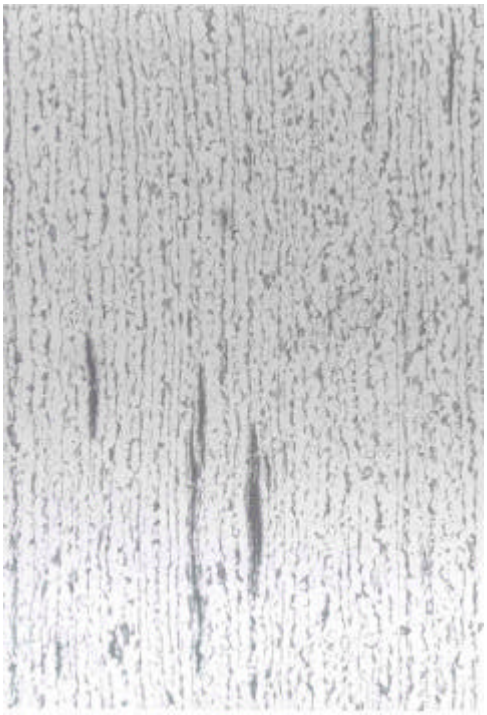
Pipe mill defect caused by failure to crimp the plate edges sufficiently before the ‘U and o’ pipe forming process.

Comment

Improve mill practice.

May be acceptable within specified limits if pipe does not see severe service. Otherwise reject the pipe.

SLAG INCLUSION



Description

Non-metallic inclusions in the pipe wall.

Cause

Caused when the source steel has a high sulphur content and manganese or calcium sulphide inclusions are formed. Their shape depends on the type of inclusion and the plate rolling process.

Comment

Slag inclusions are usually too small to be structurally significant. However, surface breaking inclusions may initiate corrosion or create a defect in a thin film pipe coating.

SURFACE LAP AT WELD

Description

Cracking in close proximity to the seam weld and running parallel.

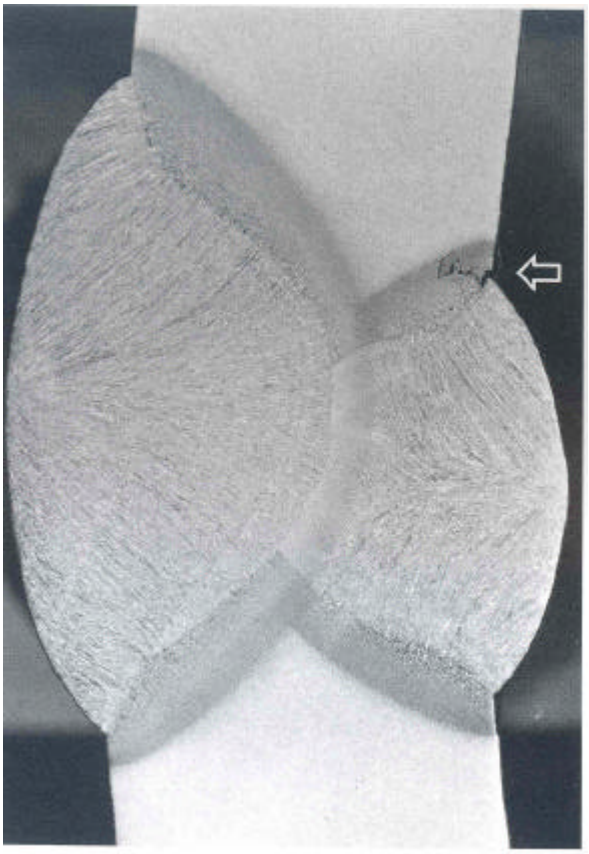
Cause

Longitudinal ingot cracks that are carried through into the rolled plate. Such cracks may occur at any point in the pipe plate. Cracks close to the edge of the plate may open up during the welding process.

Comment

Assess the structural significance of the cracks and repair or reject the pipe as appropriate.

TOE CRACKS



Description

Cracks at the junction between the submerged arc bead and the pipe surface.

Cause

Causes of toe cracks include: plate surface contamination, poor plate surface quality, rolled in scale, inclusions that lead to cracking at the weld toe. Delamination of inclusions may occur during weld cooling with subsequent cracking during cold expansion in the pipe mill or during a hydrostatic pressure test.

Comment

Use clean, high quality plate.

May only be discovered if the pipe sees severe service conditions.

TOP HAT CRACKING

Description

Solidification crack in the weld bead initiated from a change in profile at the weld fusion boundary.

Cause

Poor weld bead profile leading to concentration of strain during weld bead solidification.

Comment

Ensure correct choice of welding parameters, weld beat geometry and high purity pipe and welding consumables.

May only cause problems in severe service.

UNDERCUT

Description

A linear defect at the edge of the internal or external weld bead.

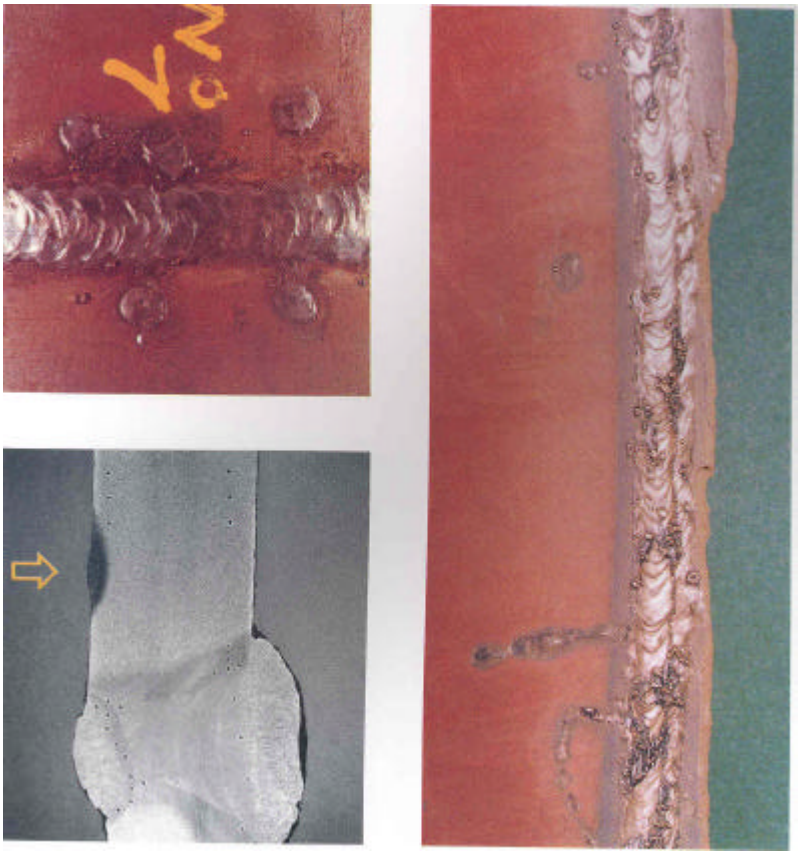
Cause

Metal is removed from the edge of the weld bead by the force of welding arc when the welding current is too high or when the angle of the welding electrode incorrect.

Comment

Undercut is usually a rounded defect and, provided it is not too deep, limited lengths of undercut are allowed in most specifications. Undercut can be repaired, if necessary, by grinding out the defect and carrying out a local weld repair.

ARC STRIKES



Description

A localized heat affected zone on the surface of the pipe. An arc strike may produce hardening, and in high strength hardenable steels cracking may occur.

Cause

An arc strike from a misplaced electrode during the welding process.

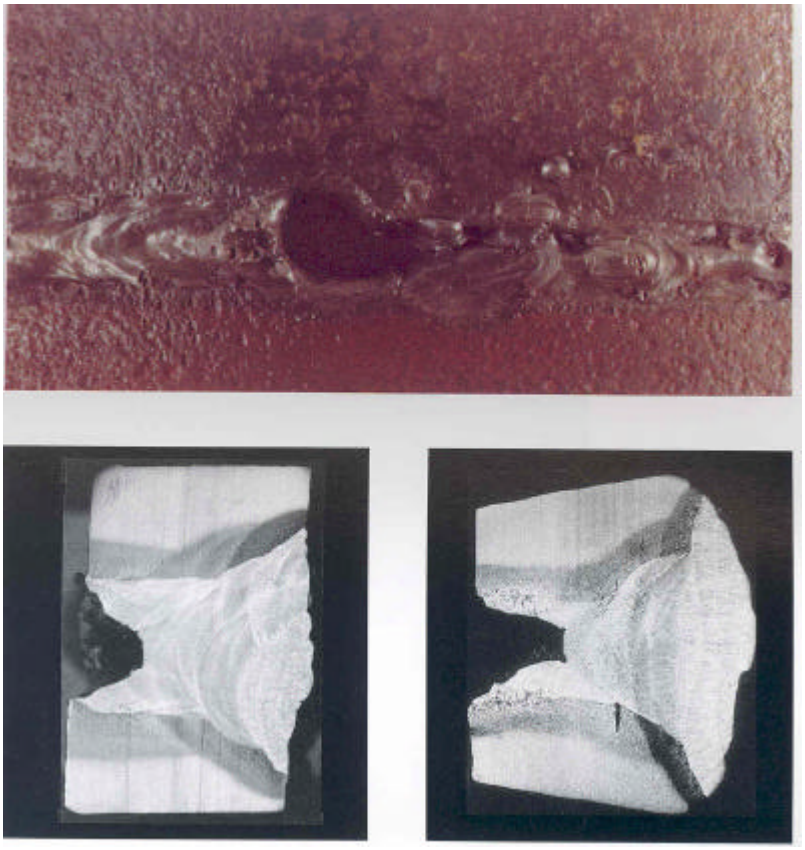
Comment

Arc strikes are an indication of poor workmanship and acceptance levels are normally defined in the welding specification. Pre-qualification of welders may also help to reduce arc strikes.

During construction shallow features may not require repair. Large features should be dressed or removed according to the weld acceptance specification.

Arc strikes are generally not a cause to excavate a pipeline. Arc strikes locates during other work may be dressed.

ARC STRIKES



Description

Local area where the root bead is missing. Often covered by the next pass. Also known as ‘window’.

Cause

Welding current too high.
Poor electrode manipulation.
Root face to small.

Comment

Use correct welding parameters and weld geometry.

CAP UNDERCUT

Description

A smooth groove between the capping run of the weld and the parent plate.

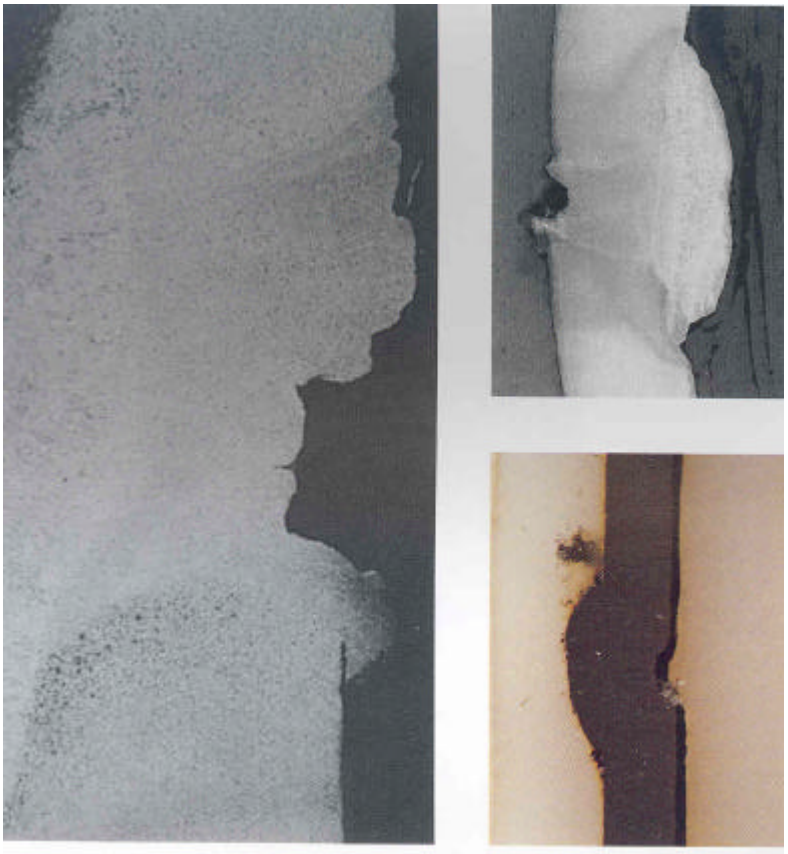
Cause

Current too high.
Incorrect electrode manipulation.

Comment

Adjust current to the electrode diameter.

CONCAVE ROOT



Description

Concave profile of the root run.

Cause

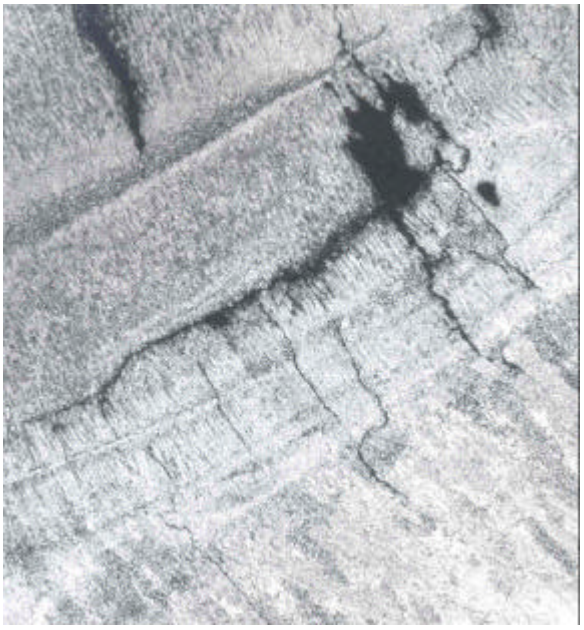
Current too high. Incorrect joint preparation, for example the root gap is too large. Concave root occurs most commonly at the 6 o’clock position on the pipe.

Comment

Adjust the current to suit the joint width.

Not significant if the contour of the root is smooth and the total weld thickness is greater than the wall thickness of the pipe.

COPPER CRACKING



Description

Fine cracking in the weld metal, often with associated copper inclusions, and concentrated at the grain boundaries.

Cause

Arc striking onto the copper backing bar. Welding torch contact tip touching the side of the weld bead.
Contamination from thermit or pin brazing compounds.

Comment

Ensure clamp backing bars are in good condition and that weld fit up is good. Alternatively use ceramic backing strips.
Avoid contact tip touching the bevel.

Usually only significant if the cracking is extensive. Small areas may be dressed by grinding followed by MPI inspection. Some standards specify acceptable levels of penetration for brazing of cathodic protection connections.

EXCESS CAP HEIGHT

Description

Excess weld reinforcement on the cap, usually greater than 3 mm. It is more common at the 6 o'clock position.

Cause

Incorrect electrode manipulation and too many weld runs.

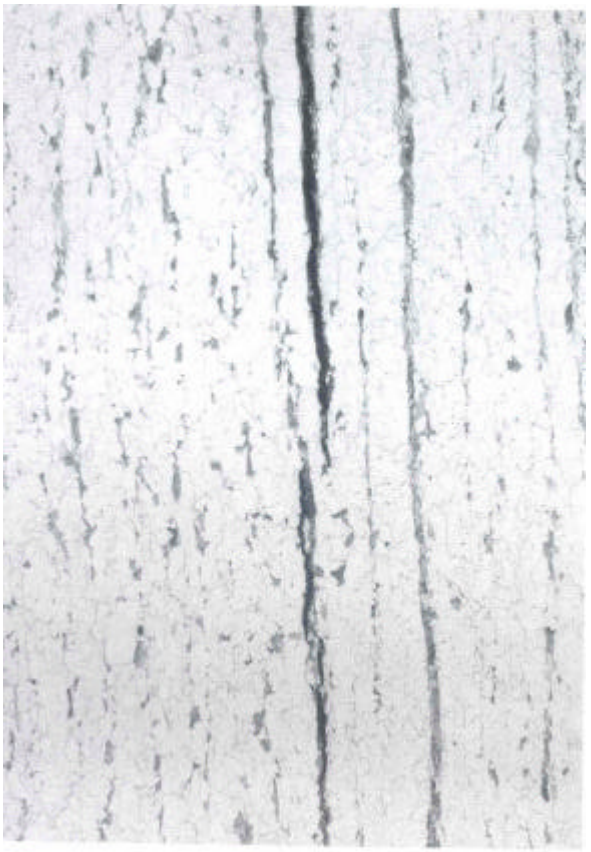
Comment

Select current to match the joint width. Adjust final filler pass height, for example by grinding, before applying cover pass weld reinforcement.

Grind to a smooth profile or remove completely by grinding and re-weld.

Excess cap height usually only has structural significance in a fatigue situation due to increased stress concentration at the weld cap – to – pipe intersection.

CENTRE LINE SEGREGATIONS



Description

Concentrations of non-metallic material in the mid-wall position including carbon and manganese rich bands.

Cause

During solidification non-metallic material may become concentrated at the center of the ingot which is the last area to solidify.

Comment

Centre line segregations are generally not structurally significant for pressure retention.

They may provide an initiation point for cracking in sour service and may contribute to weld defects.

EXCESS PENETRATION

Description

Excess weld metal in the root of the weld, usually more than 3 mm.

Cause

Too large a root gap or incorrect electrode manipulation. Excess penetration is most common at the 12 o'clock position.

Comment

Use the correct root gap and welding technique.

Grind to a smooth profile.

FISH EYES

Description

Weld metal hydrogen fissures, or ‘fish eyes’ are circular or elliptical features on weld fracture surfaces, usually tensile specimens, with a shiny grey appearance and a dark ‘eye’ at the centre.

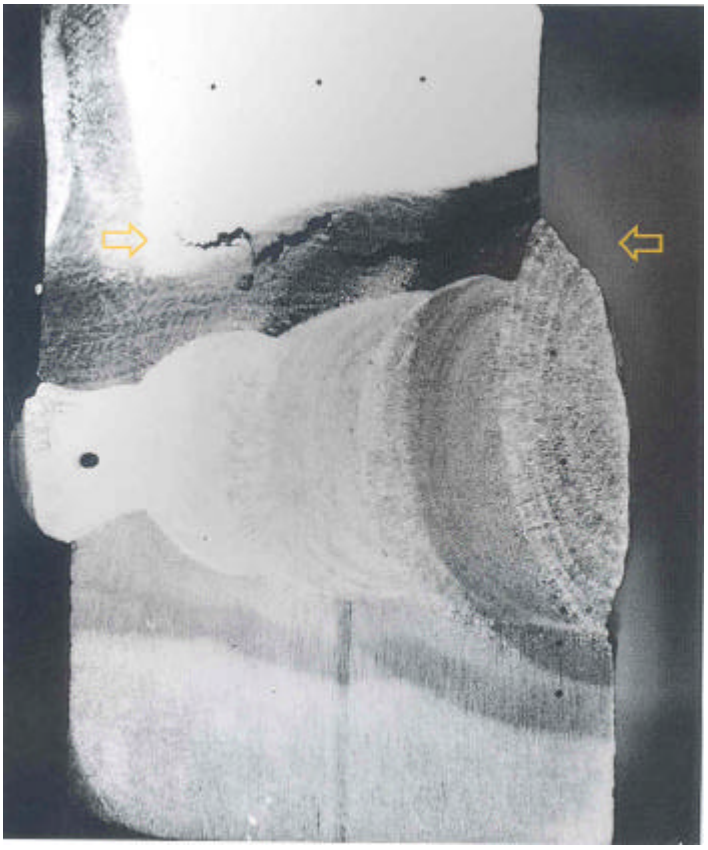
Cause

Dissolved hydrogen in the weld metal which triggers a low ductility fracture when the material is strained. Found especially in test specimens from welds made with cellulosic electrodes which are strained a short time after welding.

Comment

Regarded as an artifact caused by the testing process and of no significance for the real weld. They can be avoided by using a low hydrogen welding process, by increasing the delay time between welding and testing, or by giving the weld a low temperature hydrogen removal treatment. Repair is not necessary.

H CRACKING CAP HAZ



Description

Cracking originating at the edge of the weld cap and following the heat affected zone.

Cause

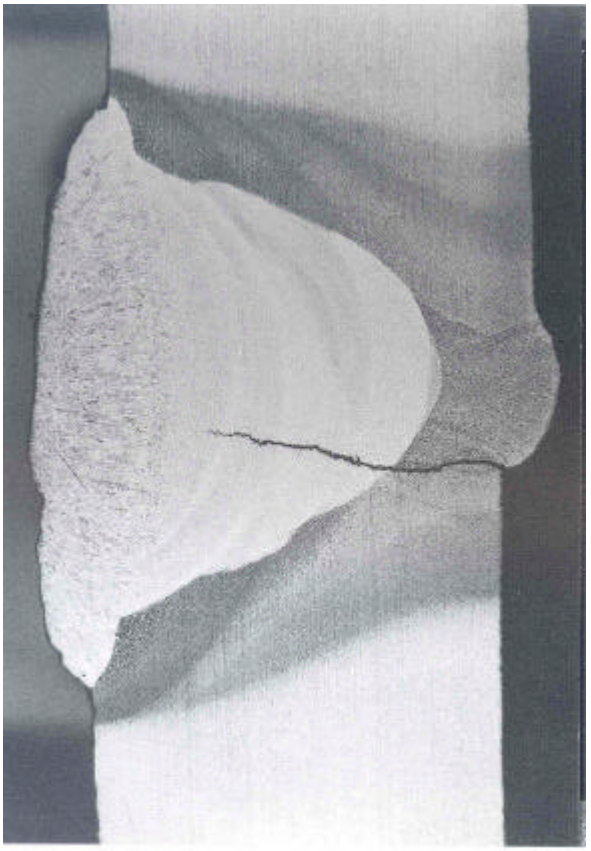
Hydrogen from the welding process. Low interpass temperature and rapid cooling after welding. Excess stress on the completed weld.

Comment

Use a low hydrogen welding process. Maintain adequate interpass temperature. Wrap the complete weld to slow the cooling rate. Avoid high stress on newly completed welds.

Cut out weld and remake.

H CRACKING, ROOT HAZ



Description

Cracks initiating in the heat affected zone of the root bead and propagating up the heat affected zone or into the weld metal. Also known as ‘cold cracks’ or ‘underbead cracks’.

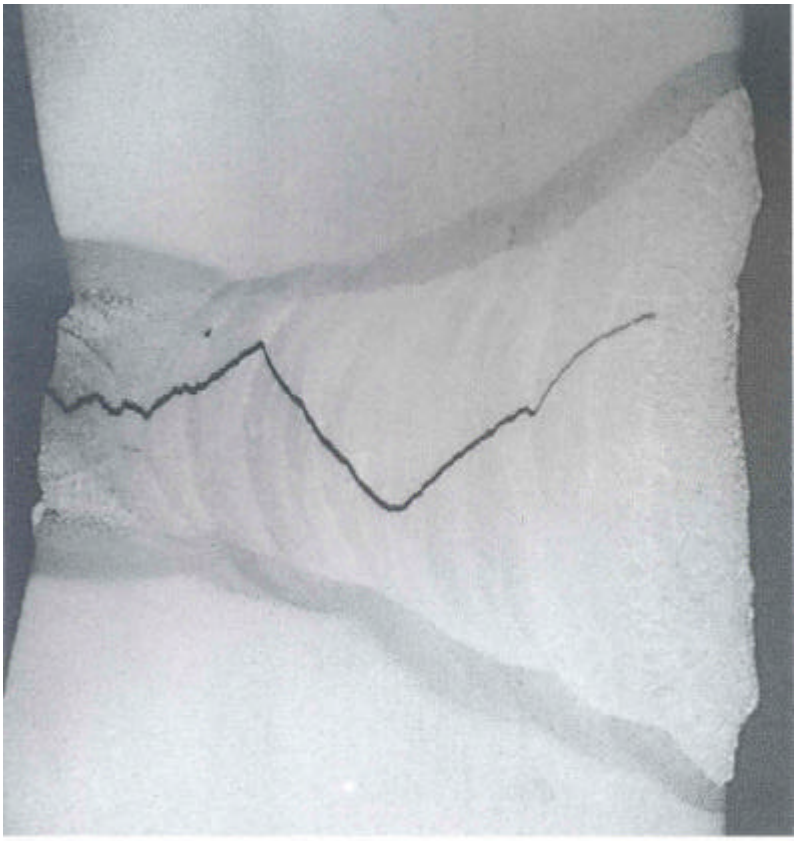
Cause

Insufficient pre-heat or insufficient interpass temperature.
Poor weldability of the pipe or fittings.
Delay between the root and hot pass welding.
Lift height too great during front end skidding.
Damp consumables.

Comment

Cut out weld and remake.

H CRACKING, WELD METAL



Description

Cracking in the weld metal. Often transverse to the weld axis and lying at an angle of 45° to the weld surface.
May have a ‘staircase’ appearance at high magnification.

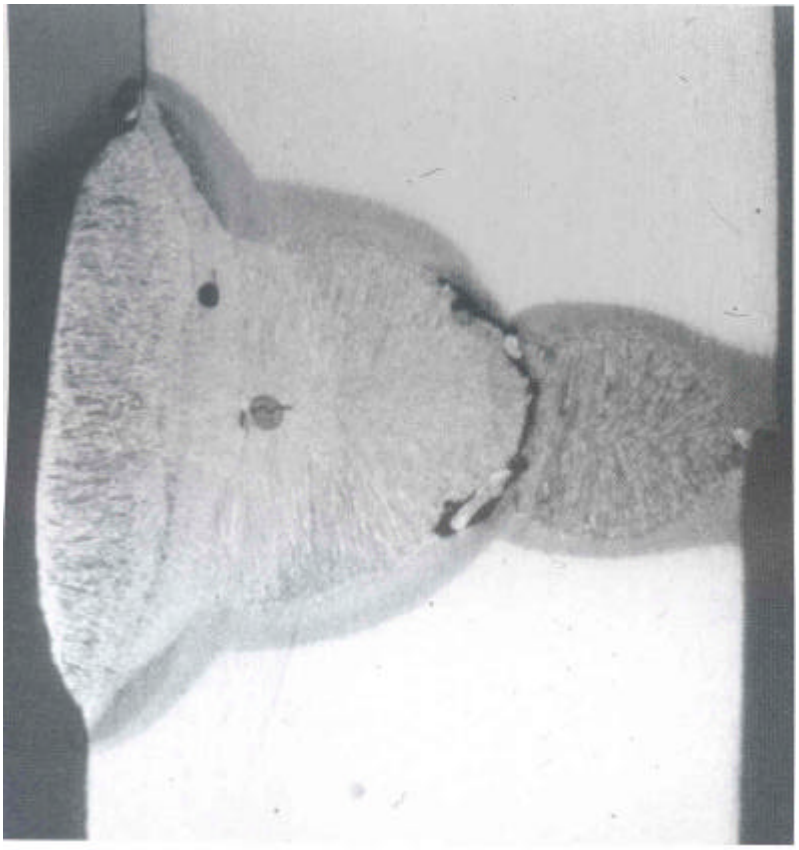
Cause

Insufficient pre-heat or interpass temperature.
Damp consumables.
High strength consumables.
Heavy wall pipe, narrow weld preparations.

Comment

Cut out weld and remake.

LACK OF FUSION



Description

Lack of fusion between adjacent weld beads. Also known as ‘cold laps’.

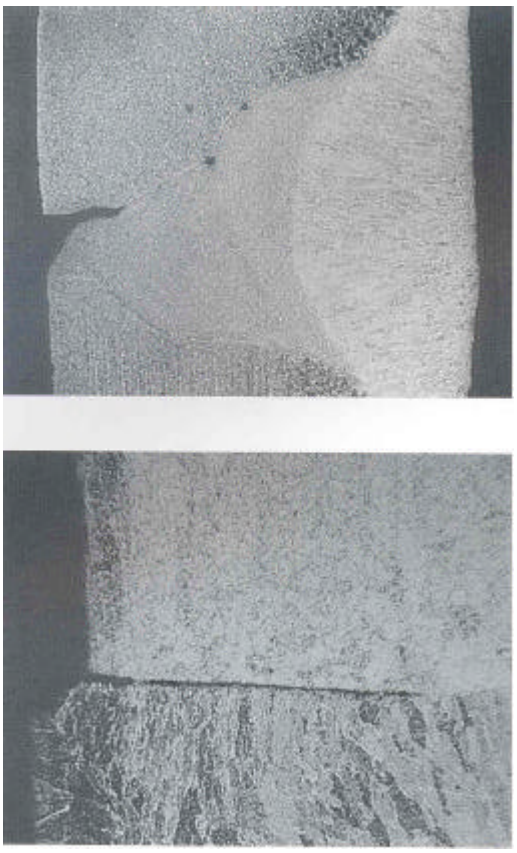
Cause

Insufficient melting of groove faces during welding.
Insufficient current.
Contamination or oxidation of the groove faces.

Comment

Adjust the current to suit the electrode diameter and welding position. Clean groove faces properly before welding.

LACK OF FUSION, ROOT



Description

Lack of fusion between the edge of a fully penetrated root bead and the root face on one side of the joint. Also known as ‘missed edge’.

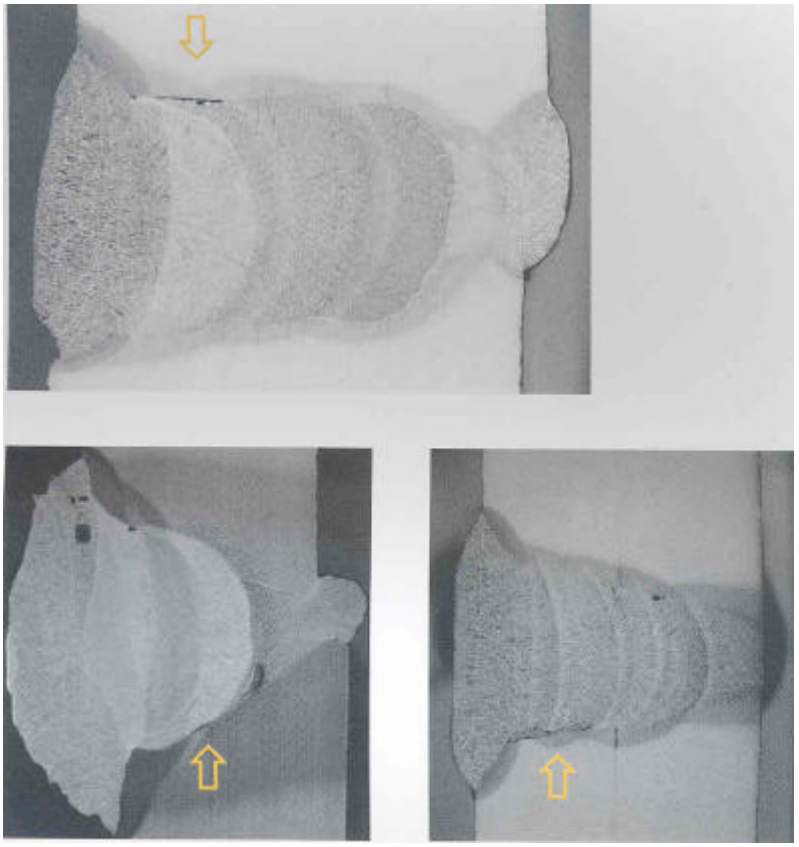
Cause

Incorrect electrode angle.
Inadequate cleaning of the root face.

Comment

May be acceptable if within specified length limits, typically 25 mm in 300 mm of weld length. Otherwise grind out and repair by re-welding.

LACK OF FUSION



Description

Occurs as a planner discontinuities between successive weld passes or between the weld bead and the pipe. Lack of side wall fusion is especially common in mechanized gas metal arc welds.

Cause

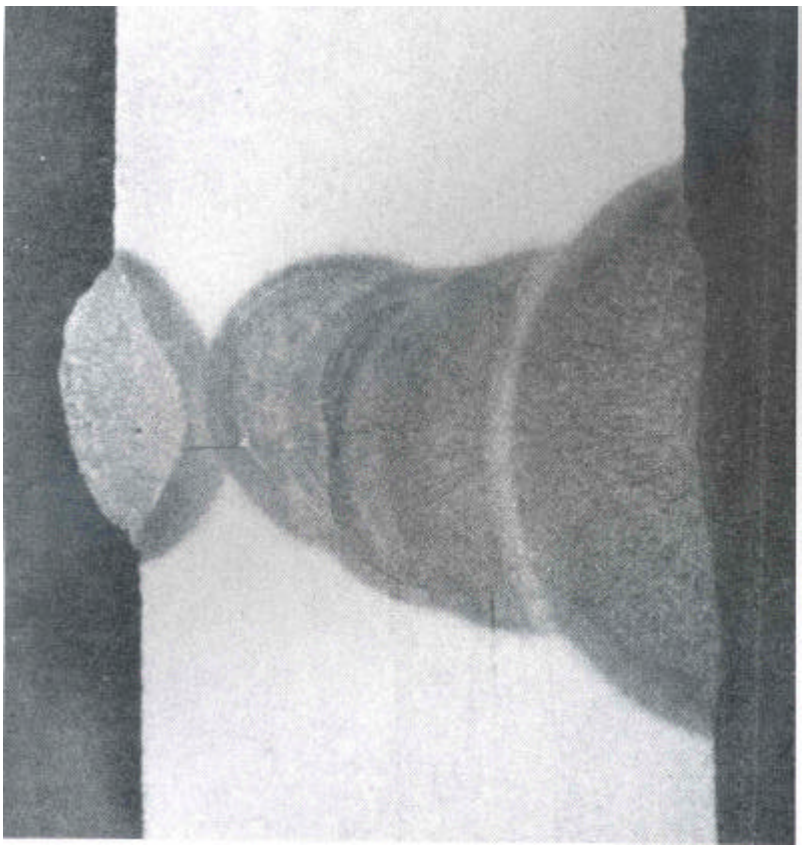
Lack of complete melting between weld beads or between the weld bead and the pipe caused by wrong electrode angle, insufficient melting current or poor cleaning of the joint faces.

Comment

Use correct welding parameters and clean the joint faces.

Limited lengths of lack of fusion are allowed in most standards, for example 50 mm in 300 mm of weld.

LACK OF INTER PENETRATION



Description

Failure of inside weld bead and outside weld bead to penetrate, especially in mechanized gas metal arc welds.

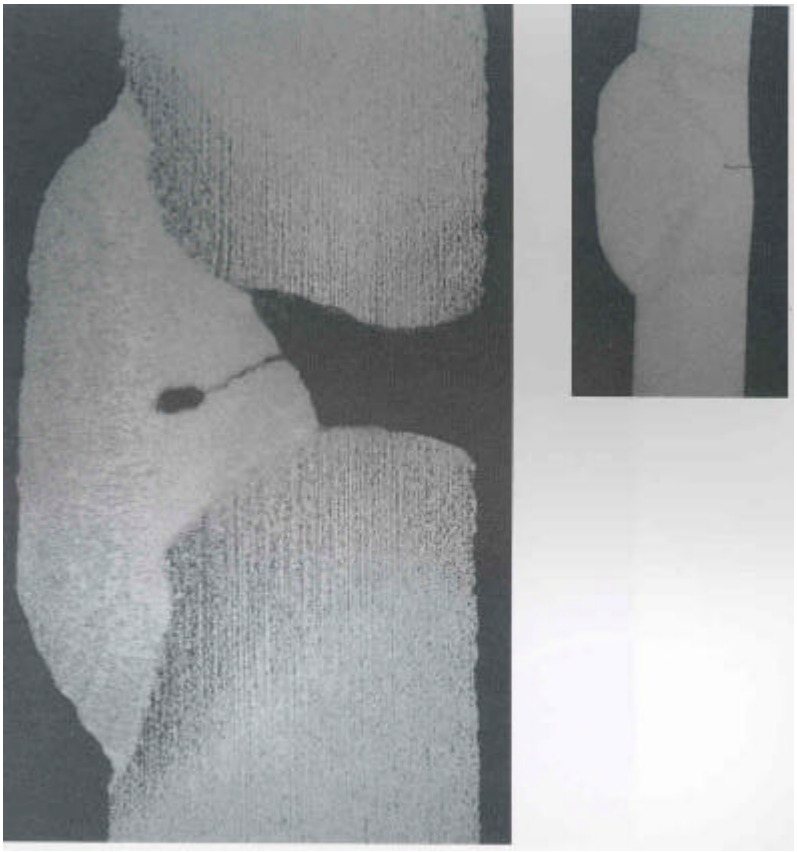
Cause

Root face to large.
Bevel angle too narrow.
Welding current too low.

Comment

May be acceptable if the dimensions are within acceptable limits, typically 50 mm in 300 mm weld length. Otherwise grind out and repair.

LACK OF PENETRATION



Description

Incomplete penetration of the weld through the full thickness of the joint to leave an unfused crevice, typically in the root run.

Cause

Root gap too small.
Root face too large.
Welding current too low.
Electrode angle incorrect

Comment

May be acceptable if within specified length limits, typically 25 mm in 300 mm of weld length. Otherwise grind out and repair.

CENTRE LINE SPLITS

Description

Cracking along the centre line of the plate in test pieces.

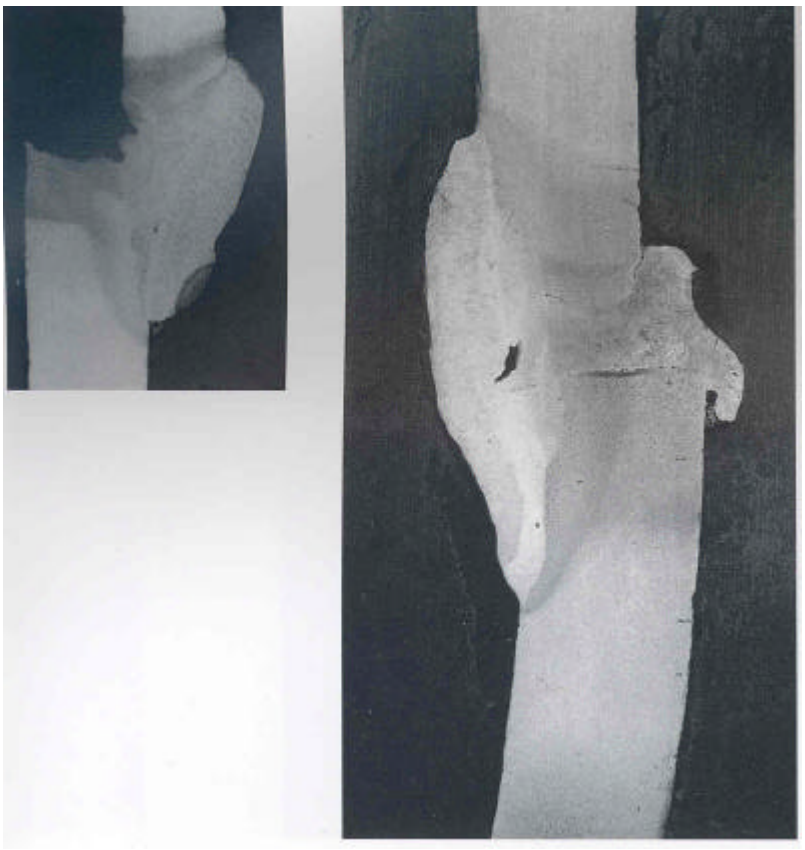
Cause

Line of weakness in the material caused by aligned inclusions or segregations.

Comment

These features are a symptom of the test and are not usually structurally significant.

MISALIGNMENT



Description

Misalignment of the pipe ends across the weld bead to produce an asymmetric weld. Also known as ‘Hi-Lo’.

Cause

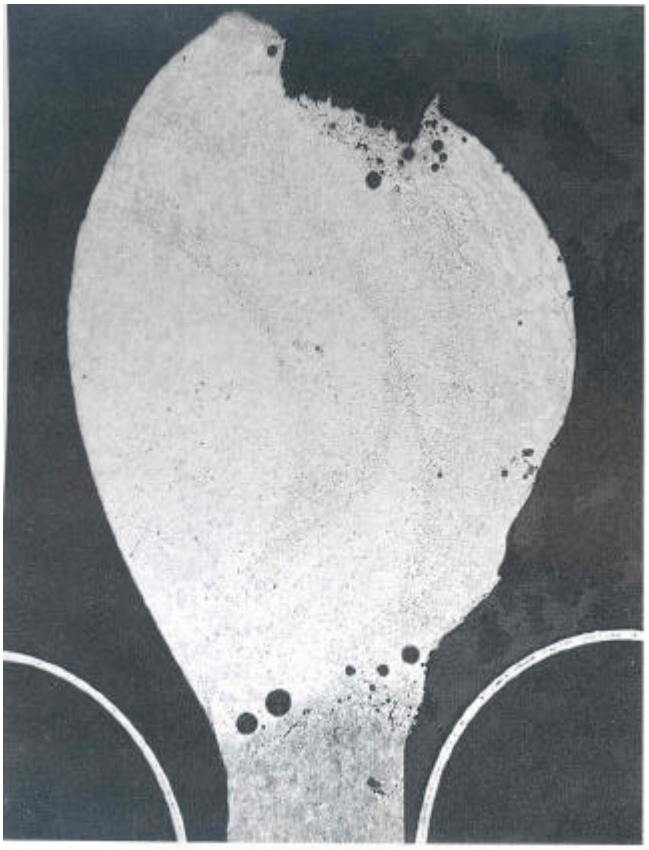
Poor fit up, possibly caused by pipe ovality, roof topping at the pipe seam weld or handling damage to the pipe.

Comment

Improve fit up by the use of stronger clamps and jointing bars.
Rotate pipes for better fit up.
Replace pipes or match ends of individual pipes.

Repair not normally required if the weld and cap form a smooth transition with the parent plate.

POROSITY, CLUSTER



Description

A group of pores within the weld metal

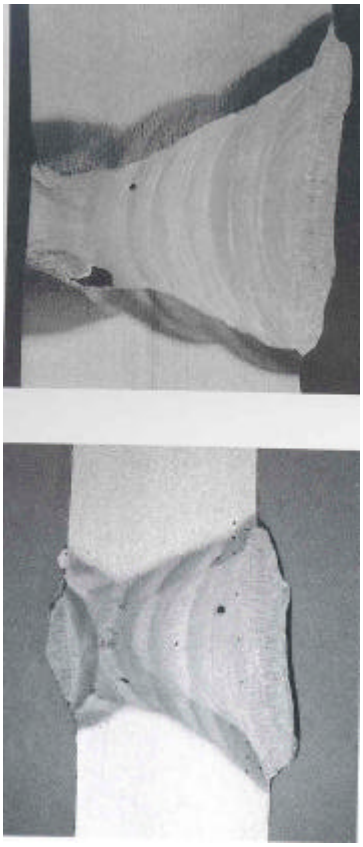
Cause

Lack of shielding gas or damp shielding gas for gas metal arc welds and gas tungsten arc welds.
Wind disruption of shield gas
Arc length too long
Weld preparation damp or greasy

Comment

May be acceptable if evenly distributed within specified limits, usually based on distribution diagrams. Otherwise grind out and repair.

PARALLEL SLAG LINES



Description

Linear voids or slag inclusions most commonly found between the first and second pass welds in manual ‘stovepipe’ welds, and often appear on radiographs as two parallel lines. Also known as ‘waggon track’.

Cause

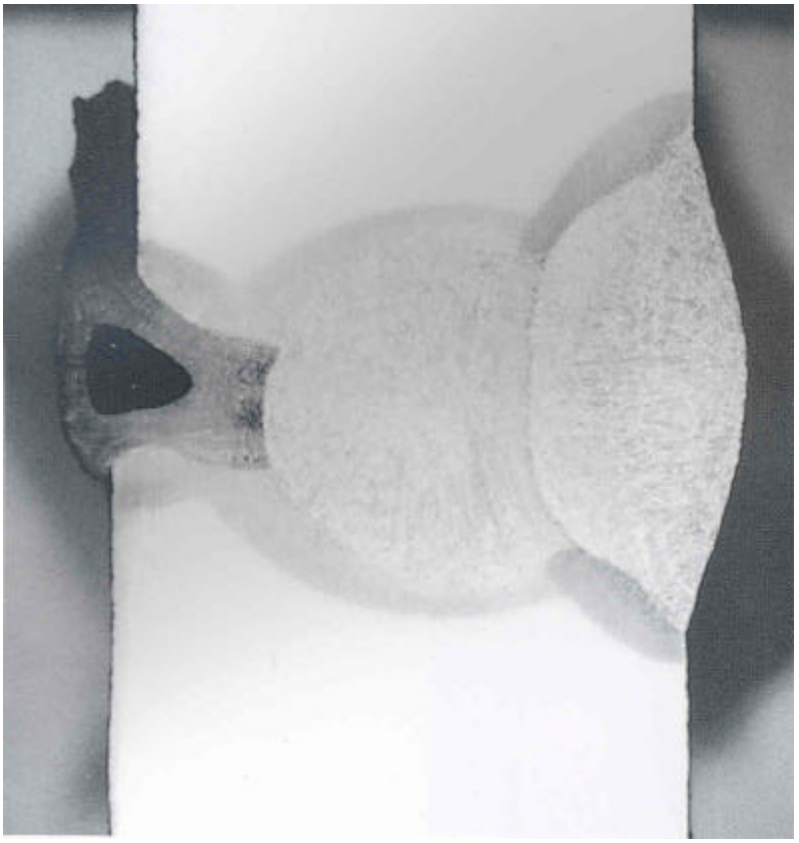
Slag resulting from insufficient grinding of the root bead external surface before making the second pass, or insufficient current used for the hot pass.

Comment

Ensure grinding of the root bead to remove convexity and to clean out slag at the sidewalls. Increase hot pass welding current.

May be acceptable within specified limits.
Otherwise grind out and repair.

POROSITY, ROOT



Description

A continuous pore in the centre of the root bead. Also known as ‘hollow bead’.

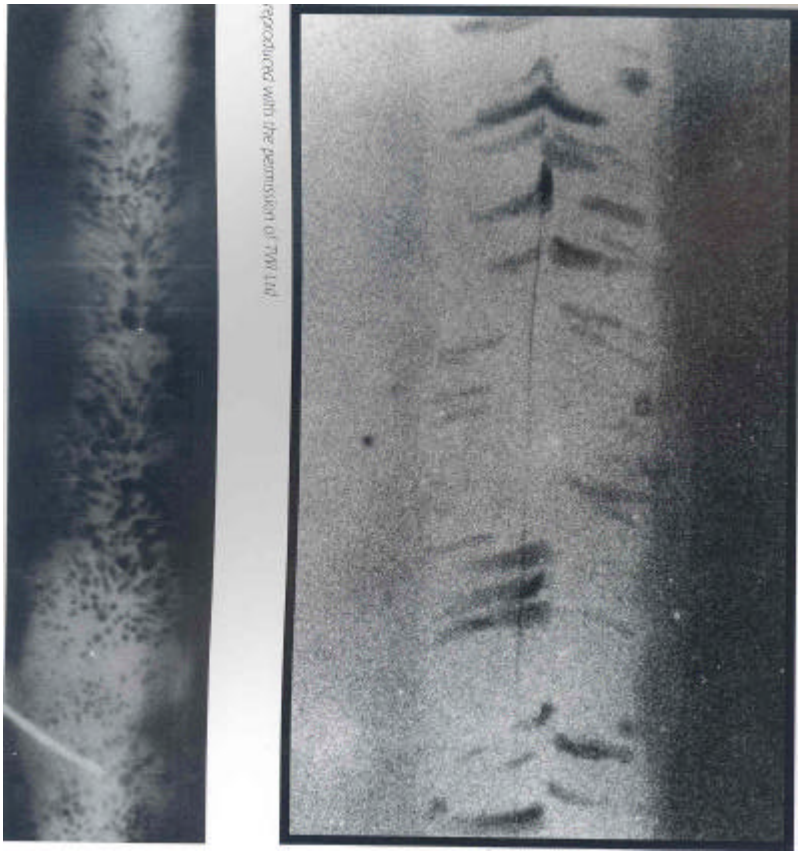
Cause

Incorrect electrode angle
Root gap too narrow
Impurities or excess alloying in the parent plate

Comment

May be acceptable within specified length limits, typically 50 mm in 300 mm weld length. Otherwise grind out and repair.

POROSITY, PIPING



Description

Elongated porosity in the weld bead. Also known as wormholes or herring bone porosity.

Cause

Dissolved gas leaving the weld pool as it solidifies.

Comment

Remove the source of dissolved gas, for example better shielding, clean weld preparation etc.

May be acceptable within specified limits, usually based on distribution diagrams. Otherwise grind out and repair.

POROSITY, SCATTERED

Description

Scattered gas pores in the weld metal.

Cause

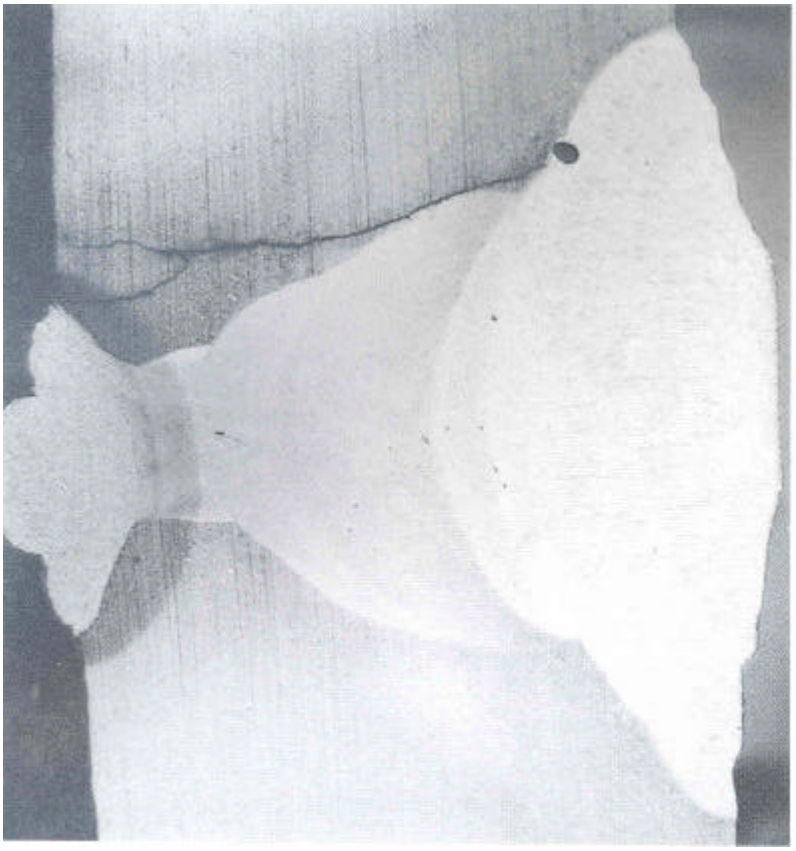
Weld pool solidifying too rapidly whilst supersaturated with dissolved gas.

Comment

Remove source of dissolved gas. Increase welding heat input.

May be acceptable within specified limits, usually based on distribution diagrams. Otherwise grind out and repair.

REPAIR, WELD CRACK



Description

Hydrogen cracks associated with repair welds.

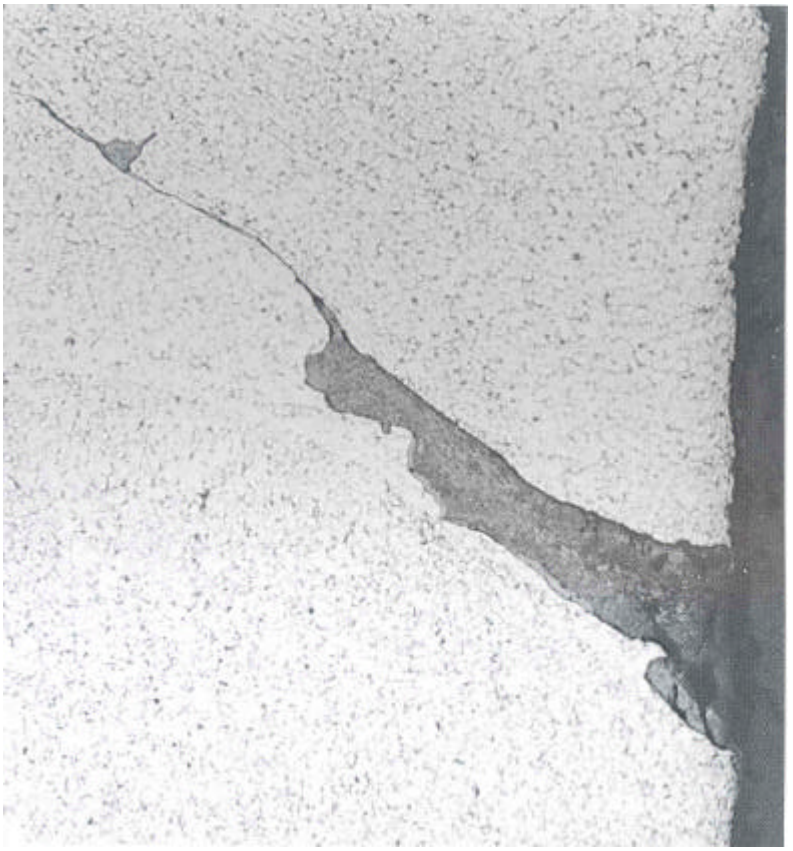
Cause

Poor repair welding practice such as, lack of pre-heat or use of single back weld run instead of two.

Comment

Cut out the weld and remake it.

ROOT BEAD SLAG INTRUSION



Description

Trapped slag at the inside edge of the root weld bead, often associated with a crack lack of fusion defect.

Cause

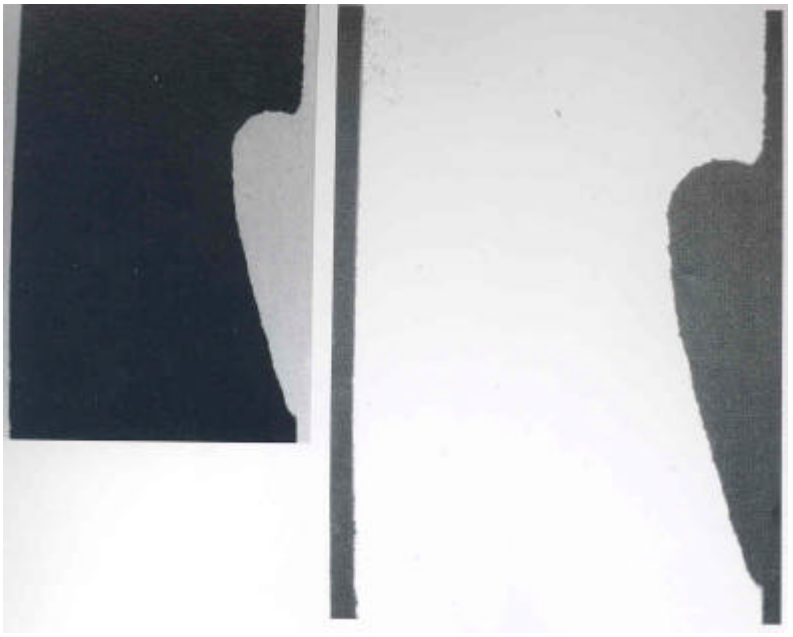
A feature of stovepipe welding with cellulosic electrodes which is not properly understood but is thought to be associated with poor weld pool fluidity.

Comment

Pay particular attention to weld preparation dimensions and joint fit up. Change to low hydrogen electrode or other root bead process.

May be acceptable if not extensive. This is not covered by the normal pipe welding standards, and is often interpreted as lack of root fusion, and those defect limits are applied.

INDENTATIONS



Description

A depression in the pipe surface. When viewed in section the grain structure in the steel follows the outline of the depression.

Cause

Pieces of scrap or foreign bodies that have been rolled into the plate surface.

Comment

Commonly these features are relatively shallow and are too small to be structurally significant.

Indentations should be checked with respect to the pipe specification.

ROOT UNDERCUT

Description

A groove or channel melted into the pipe metal adjacent to the root or cap run which has not been filled with weld metal.

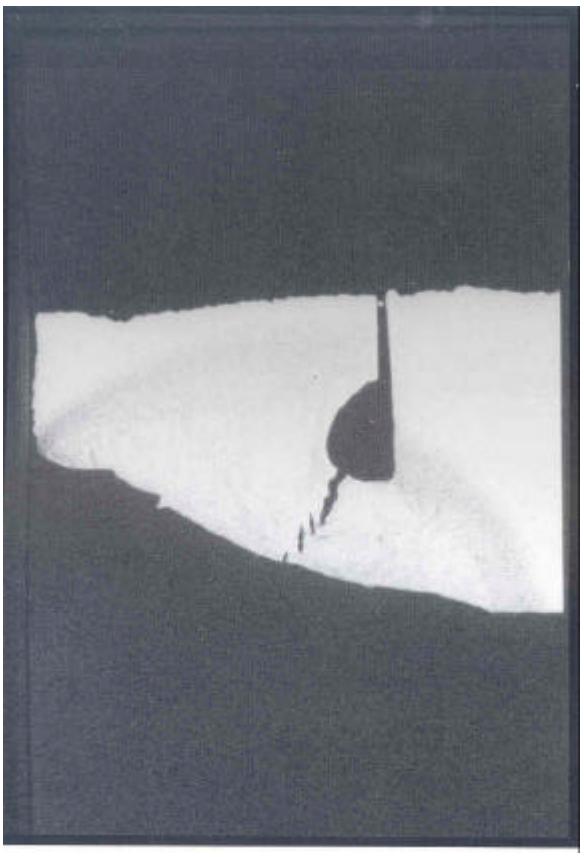
Cause

Too high a welding current
Incorrect electrode angle

Comment

May be acceptable within specified length limits, typically 25 mm in a 300 mm weld length. Otherwise grind out and repair.

SOLIDIFICATION CRACKS



Description

Crack in the centre of the weld bead, especially within hot pass. Also known as ‘hot tear’

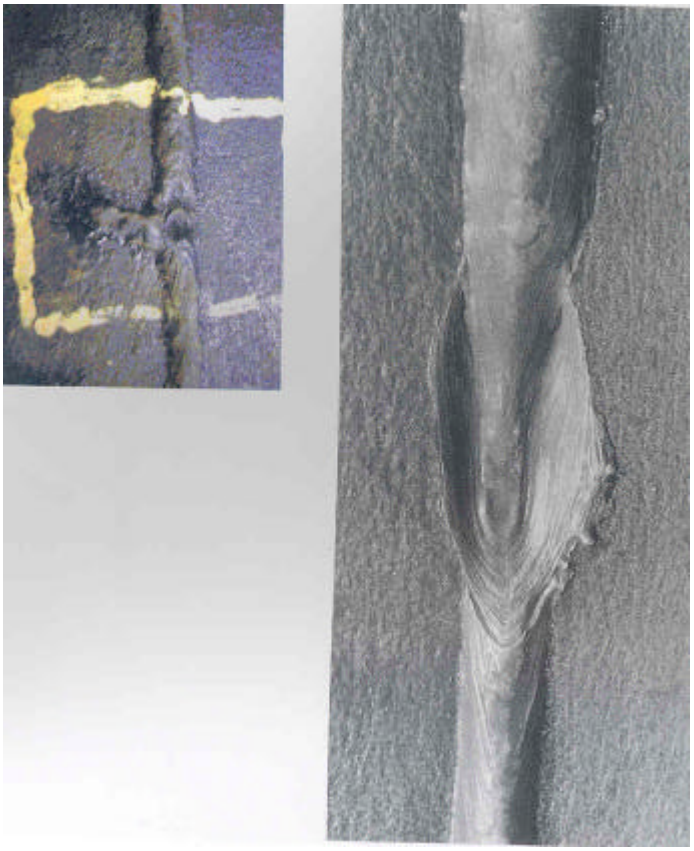
Cause

Poor weld bead solidification pattern, for example a large depth to width ratio. Excessive restraint/ stress on the weld during solidification.
Impurities in the weld pool.

Comment

Correct deficiencies. Change weld consumables. Grind out and repair.

STOP START DEFECT



Description

A lack of fusion, a lack of fill or a lack of penetration at the stop / start position, often in the root bead. Also known as ‘poor pick up’.

Cause

Failure to overlap the stop / start position when changing electrodes.
Failure to grind the crater, failure to fill the crater or failure to establish weld pool properly when re-striking.

Comment

Visually acceptable within specified limits, depending on the type of defect.

TRAPPED SLAG

Description

Slag trapped between individual weaves of the weld run. Also known as ‘slag holes’.

Cause

Current too low
Weaving technique too rapid

Comment

May be acceptable within specified limits.
Otherwise cut out and repair.

TUNGSTEN INCLUSION

Description

Isolated inclusions of undissolved tungsten in the weld bead. Appears as a white spot on the weld radiograph.

Cause

Contact between the tungsten electrode and the weld when gas tungsten arc welding is used, especially manual GTAW. Occurs especially within stop /starts.

Comment

Avoid contact between the tungsten electrode and the weld pool.

Use high frequency starting or soft start equipment instead of the conventional touch starting.

May be acceptable within specified limits, typically specified as a maximum number per weld. Otherwise grind out and repair.

BUTT WELDED PATCH

Description

Butt welded patch in a pipeline

Cause

During construction a manhole has been cut into a pipe to gain access to the inside of the pipe for weld repairs. The ‘cut out’ is then welded back into the pipeline with a butt welded.

Comment

This is unacceptable construction practice. The area of the patch should be cut out and replaced or repaired with a full encirclement sleeve.

COLD BEND KINK

Description

Circumferential kink or ripple in the pipe that has been subject to cold bending in the field

Cause

Caused by poor control of the field bending process

Comment

Discard the pipe or cut out affected.

CONTACTS

Description

The pipeline is in electrical contact with ‘foreign’ structures such as pipe supports or reinforcing bars in concrete

Cause

Poor construction practice

Comment

Electrical contacts create a drain on the applied cathodic protection current and may prevent effective protection. Galvanic or interference current corrosion may result and lead to rapid pitting and through wall penetration in the affected area.

ECCENTRIC TOUCHING CASING

Description

The casing is not aligned parallel with the carrier pipe and, in extreme cases is in contact with the carrier pipe

Cause

Poor construction practice or ground movement after construction

Comment

Electrical contact between the casing and the carrier pipe may create a local drain on the applied cathodic protection and create a localized corrosion cell.

INCORRECT PIPE SUPPORT

Description

Above ground pipe is supported on objects other than manufactured or shaped pipe supports.

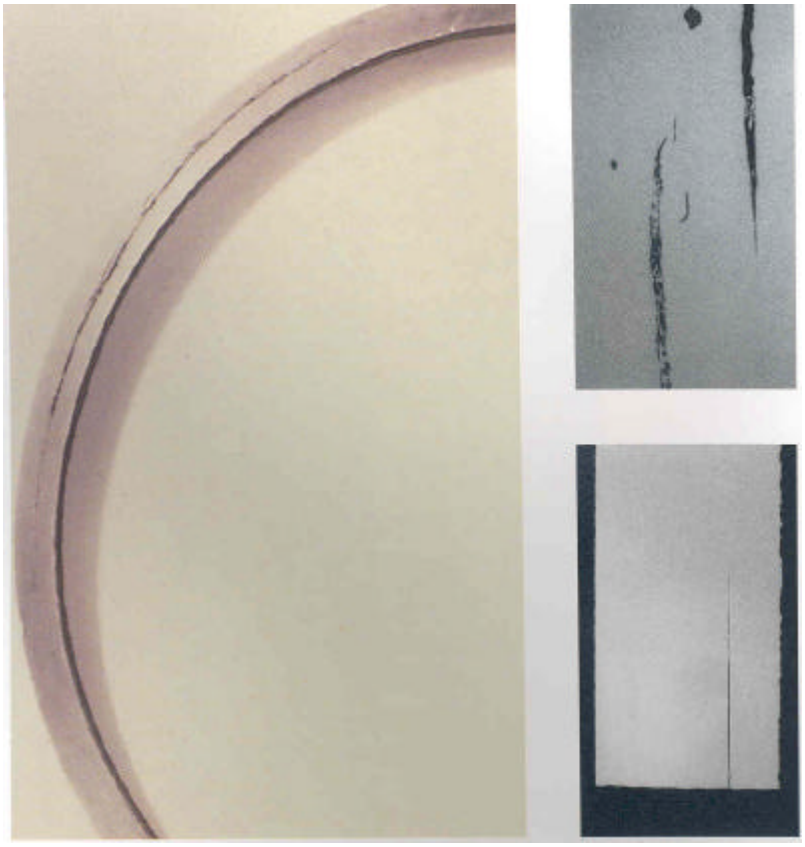
Cause

Poor construction practice

Comment

Incorrect pipe supports may create problems that include stress concentration, damage to the protective coating or electrical contacts that interfere with the efficient operation of the applied cathodic protection.

LAMINATIONS



Description

A discontinuity lying parallel to the pipe surface, usually marked by a concentration of non-metallics.

Cause

Rolling-out of inclusions, blow holes or pipes in the parent material.

Comment

Large laminations may be structurally significant. Some older pipelines contain pipes with large laminations that have not created a safety hazard in many years service.

Surface breaking laminations may contribute to coating faults and may serve as an initiation point for pitting corrosion.

Superficial laminations may be removed by grinding before application of the coating.

LACK OF COVER

Description

Shallow depth of burial

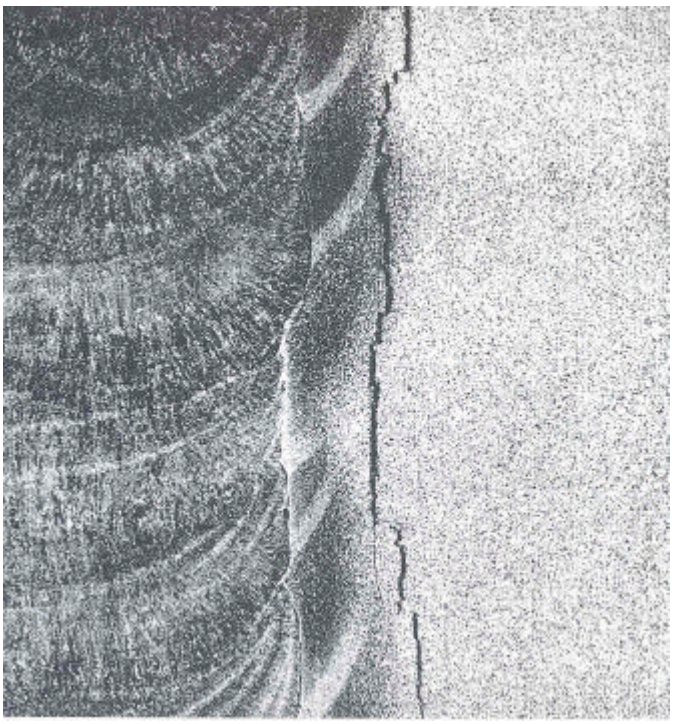
Cause

Poor construction practice

Comment

The pipe is particularly vulnerable to third party mechanical damage and vandalism.

LAMELLAR TEARING



Description

A crack like feature within the plane of the plate

Cause

Lamellar tearing is associated with fillet welds. Through thickness stress, associated with the welding process, causes opening in non-metallic inclusions.

Can occur during construction under attachment welds but lamellar tearing is more likely to occur when welding fittings to old pipelines for repair or for hot tapping purposes.

Comment

Lamellar tearing is most marked in dirty plate. Small tears may not require attention but large tears should be assessed.

MITRE BEND

Description

Mitre bends, also known as ‘lobster back bends’ are made by welding together short pieces of pipe with mitred ends.

Comment

Mitre bends are not suitable for high pressure pipelines. Possible problems include difficulty in ensuring satisfactory weld quality and poor fatigue performance of the resulting bend.

Mitre bends should be replaced with forged bends in high pressure pipelines.

UNPROTECTED PIPE

Description

The pipeline is exposed above ground without security fencing or other protective measures.

Comment

Exposed pipe may be susceptible to vandalism, sabotage or accidental damage.

ARCING

Description

Severe, localized metal loss which may show signs of molten material, such as solidified globules.

Cause

Direct shorting from power lines

Comment

In this fault condition through wall penetration may occur in a very short time.