

Oil and Gas Pipeline Design, Maintenance and Repair

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Part 11: Pipeline Rehabilitation and Repair Techniques

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Repair Strategy

Addresses six key decisions

- Repair techniques
- Materials (chemistry, mechanical properties (corrosion resistance),
- Design (flow and system logic, sizing),
- Fabrication (joining, welding, heat treatment),
- Examination (NDE of the failed component and the repair),
- Testing (hydrotest, pneumatic test, leak test

Replacement

- most common practice for repairing pipe sections
- new component or subassembly should fully comply with the construction code
- Important, carefully and clearly specify lockout, tagout, depressurization, draining and venting the pipe before cutting or opening the system

Grinding Out Defects

- Used when base metal or welds contain fabrication or service-induced defects (weld flaws, arc burns, gouges or cracks)
- Ground surface is then examined by liquid penetrant or magnetic particle to confirm that the defect has been removed
- The ground out area may be left as-is, without weld deposit, if the remaining wall thickness exceeds the minimum required by code

Grinding Out Defects

- Safe length and depth of grinding are given by [Rosenfeld]

$$L \leq 1.12 \sqrt{Dt \left[\left(\frac{d/t}{1.1(d/t) - 0.11} \right)^2 - 1 \right]}$$

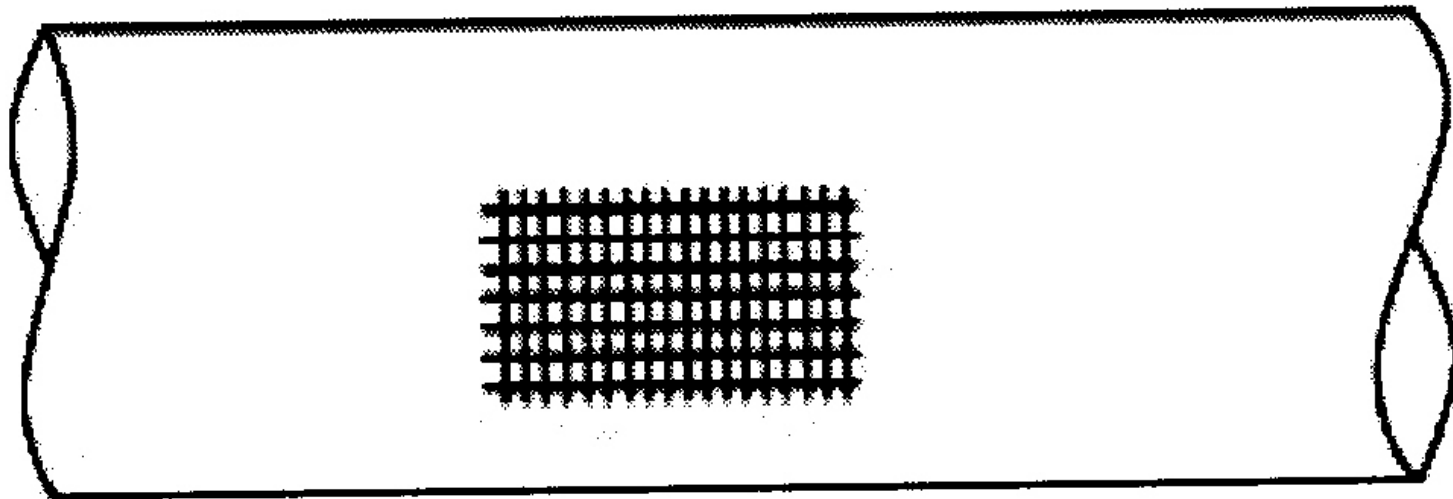
where

- L = length of grinding, in
- D = pipe diameter, in
- t = nominal wall thickness, in
- d = depth of grinding, in

Weld Overlay

- Referred to as direct weld deposit
- Consists in depositing weld reinforcement on the surface of a pipe
- Several considerations apply in the selection and application of weld overlay repairs
 - Compatibility of the weld
 - Sequence of weld bead deposition
 - Number of passes
 - Necessity to minimize residual stresses

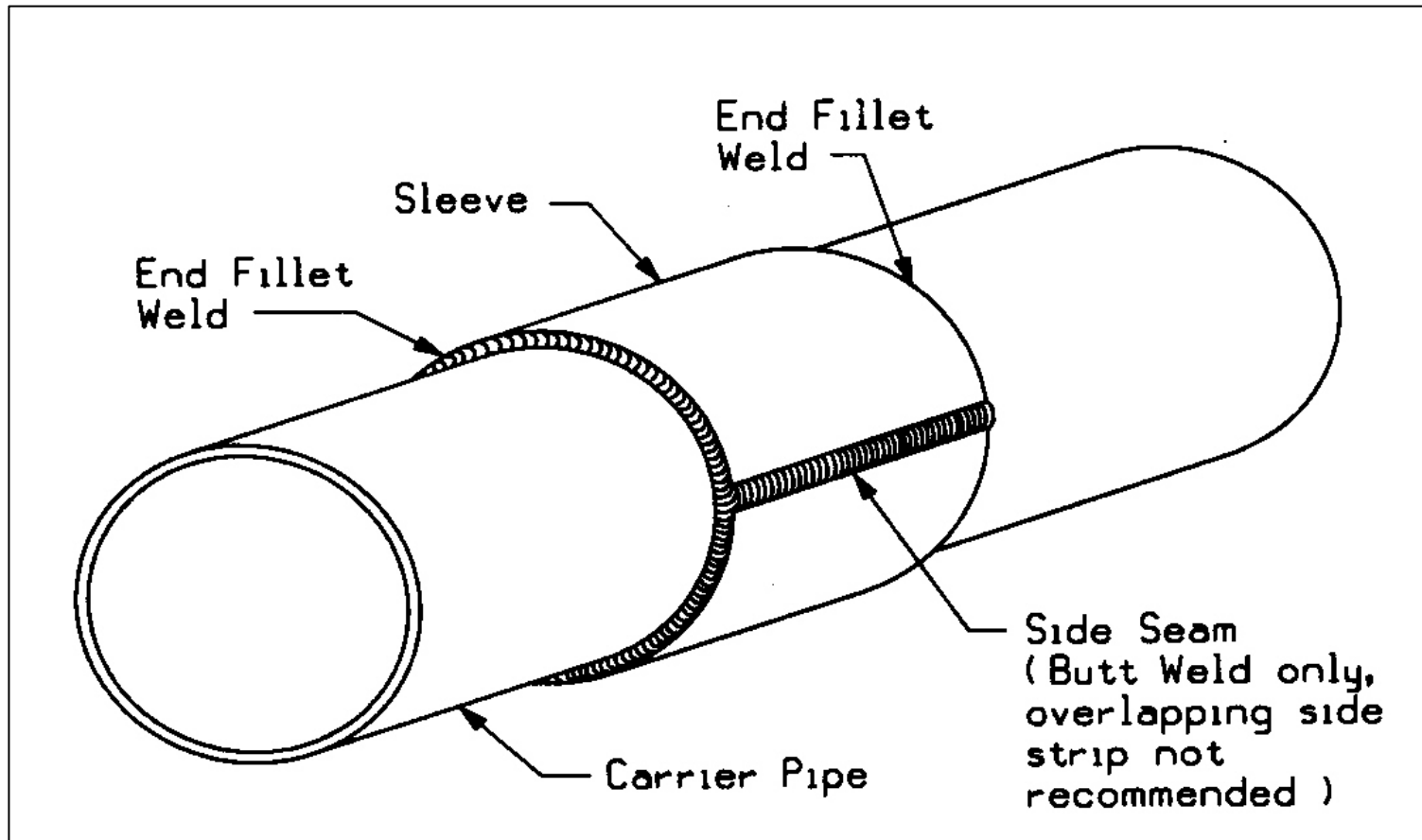
Weld Overlay



Full Encirclement Sleeve

- A degraded pipe can be repaired with a full encirclement split sleeve
- A type A sleeve (no end closure welds) serves to reinforce a locally corroded area
- With a type B sleeve (with the two end closure welds) the sleeve serves the same role
- The ends of type A sleeve should be sealed to avoid corrosion in the pipe-to sleeve annulus
- Type B sleeves are used to repair a pipe crack; the crack must be shown to be stable and not able to propagate beyond the sleeve

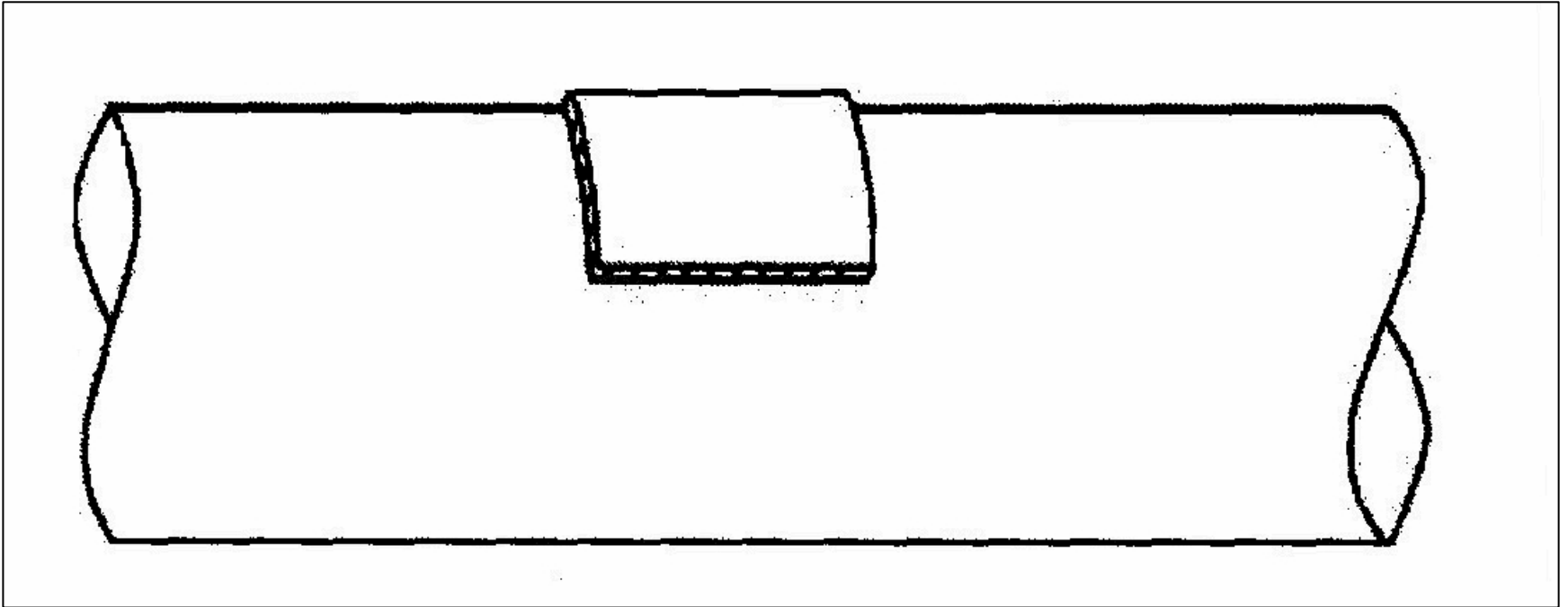
Full Encirclement Sleeve With Circumferential Weld



Fillet Welded Patch

- Repairs local flaws
- Can be a circular or square steel patch to the pipe outer diameter
- Common repair technique [API 510, API 570], except for pipelines where patches are not used if the hoop stress exceeds 20% of yield
- For hazardous liquid pipelines, ASME B31.4 limits the patch length to 6" and limits its use to pipe sizes 12" and less.
- A variation of the fillet-welded patch is to repair a small pitting leak by fillet welding a small bore fitting (NPS 2 or smaller) to cover the leak

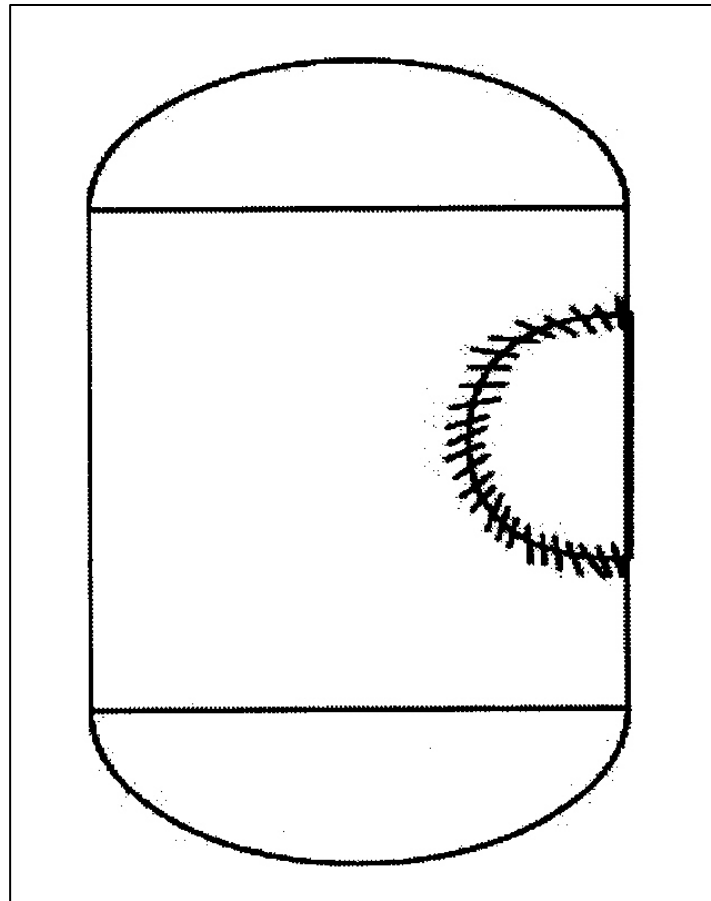
Fillet Welded Patch



Flush Welded Patch

- damaged section is cut out of the tank, vessel or pipe and replaced by a section of the same size
- butt welded flush to the existing pipe
- mostly used for the repair of pressure vessels and tanks, and more rarely for piping with smaller diameter
- If the patch is rectangular, it should have rounded corners to reduce stress concentrations.
- Post-weld heat treatment will be required

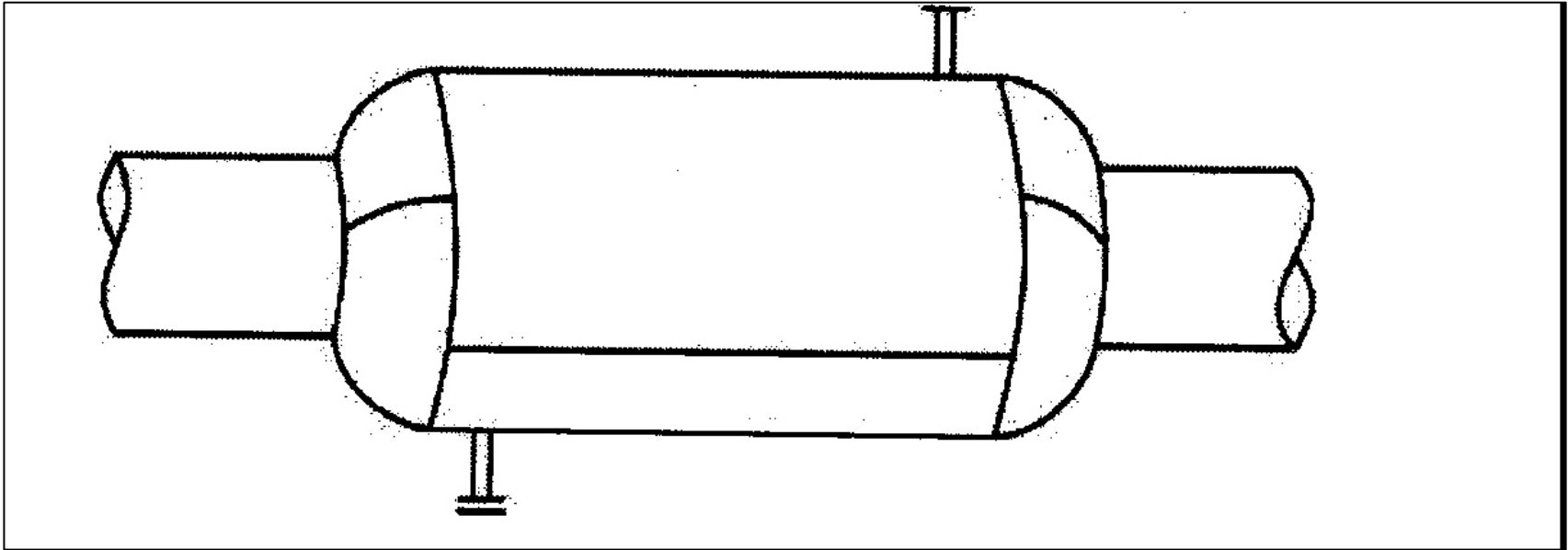
Flush Welded Patch



Welded Leak Box

- Consists of a pipe jacket with end pieces, placed around the section to be repaired, and seal welded to the pipe
- A leak detection drain or pressure gage can be added to indicate the onset of leakage
- The box must be sized to contain the design pressure of the leaking fluid
- The stability of a through wall crack should be analyzed, with adequate safety margins,

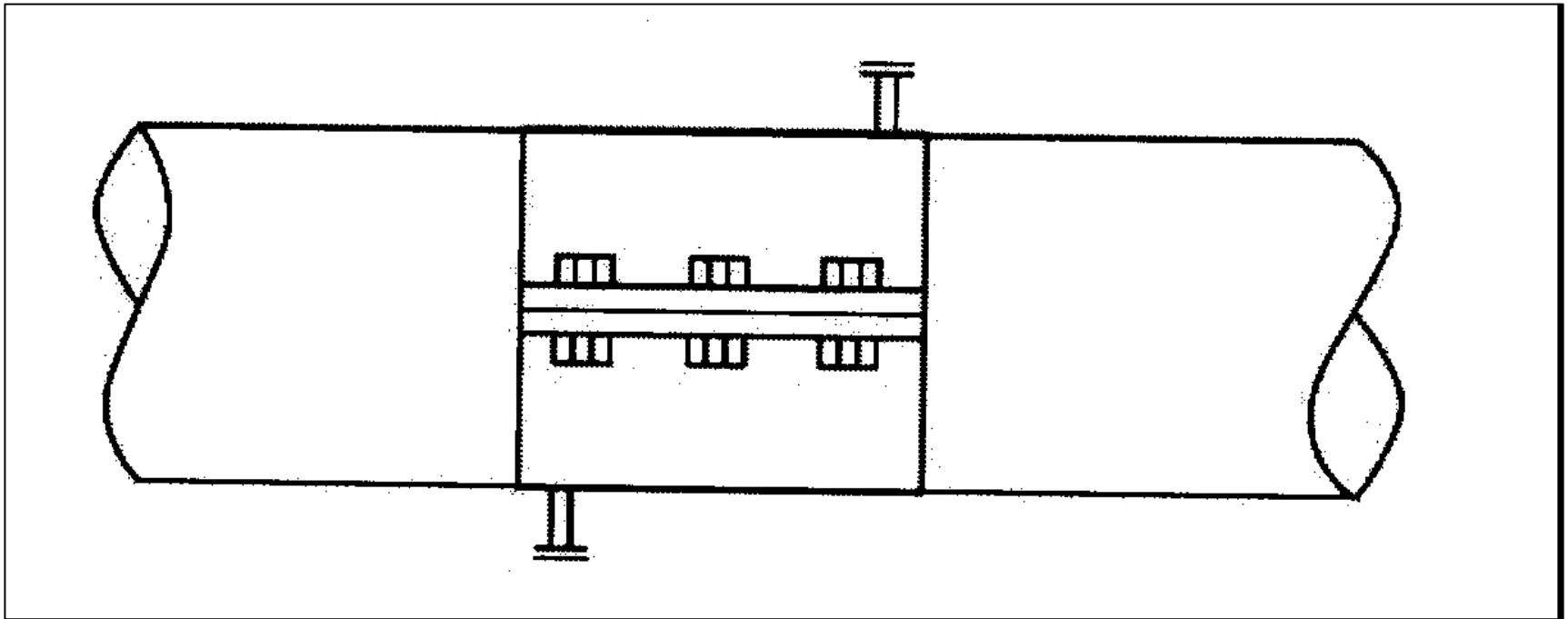
Welded Leak Box



Mechanical Clamp

- a housing comprised of two half shells, with two end gasket rings
- Tightened against the pipe outer diameter by bolting
- Commonly used in power and process piping systems
- Certain clamps may be welded to the pipe, in which case the clamp may be pressure tested and the welds examined
- Mechanical clamps are also permitted for temporary repair of nuclear power plant

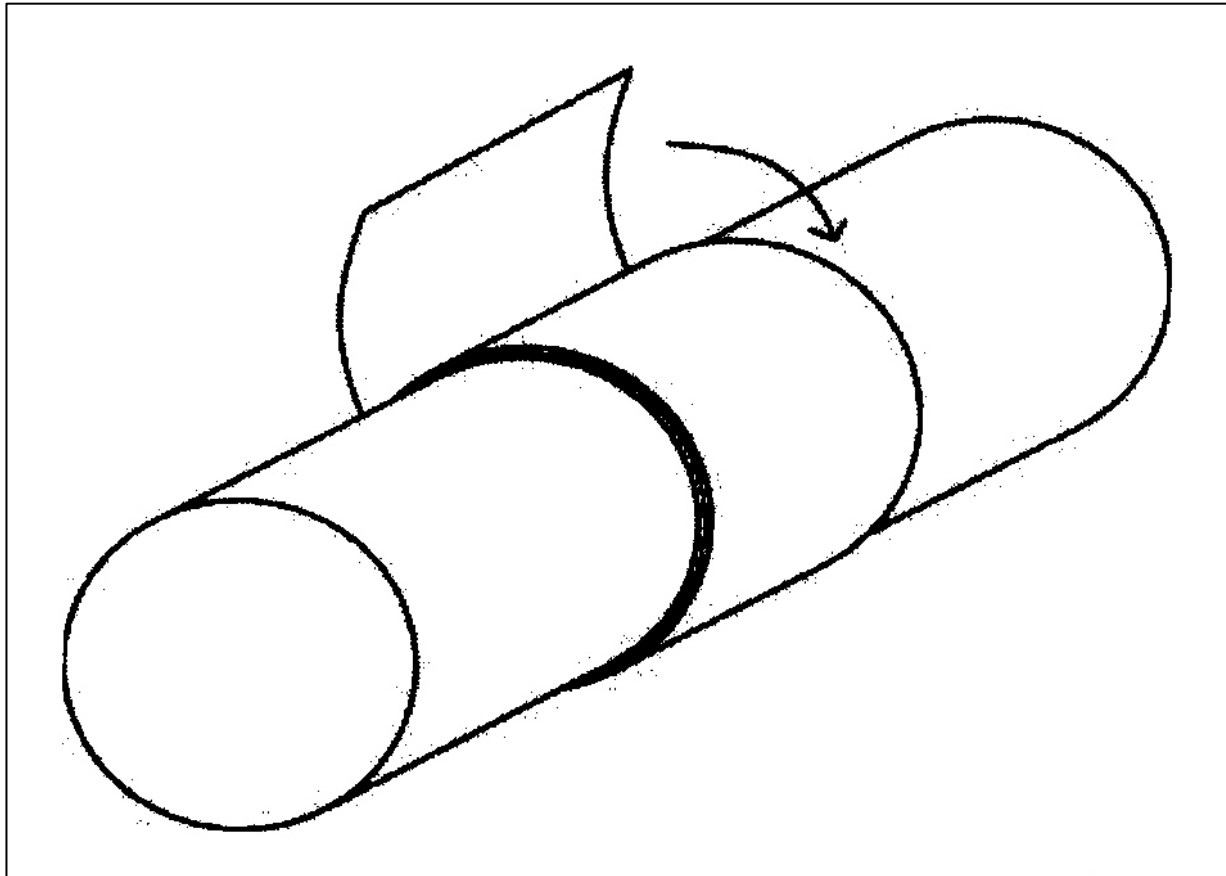
Mechanical Clamp



Composite Overwrap

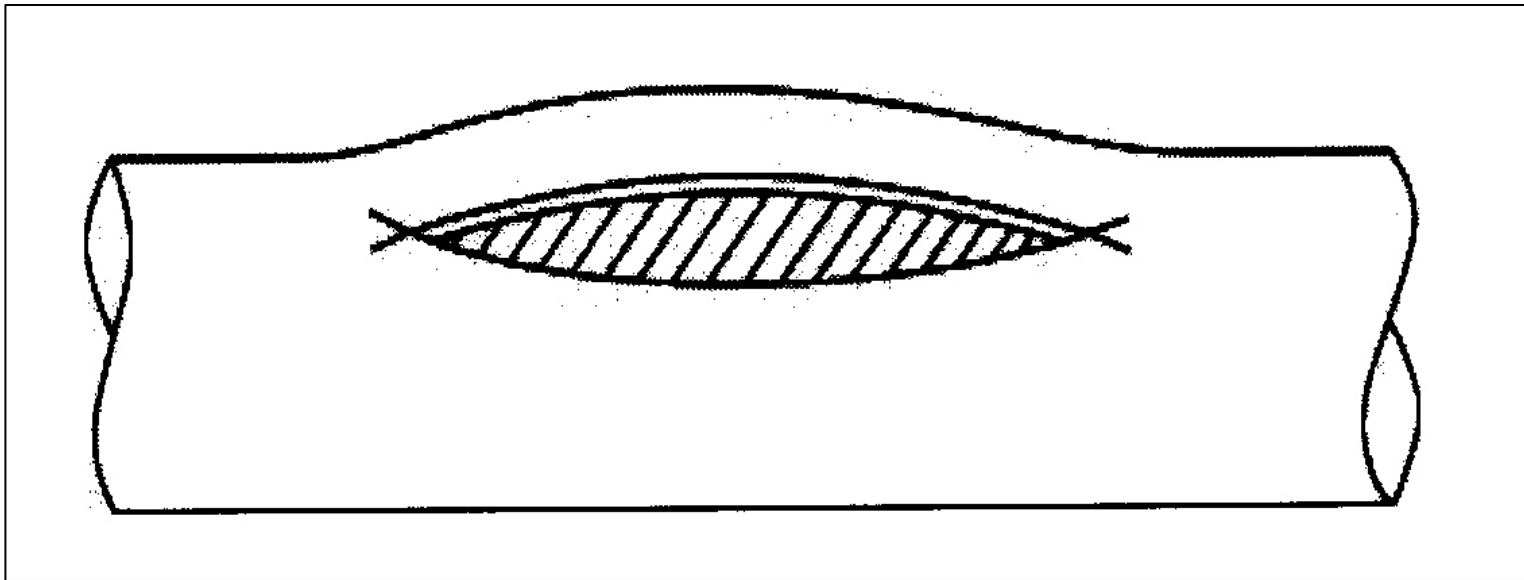
- A repair technique for corroded or dented pipes or pipelines that does not require welding
- Some follow the same principle as a type A full encirclement sleeve
- Objective is to reinforce the corroded wall thus avoiding outward bulging of the pipe wall
- Other overwrap sleeves: a resin impregnated fiber glass is wrapped by hand several times around the leaking pipe,

Composite Overwrap

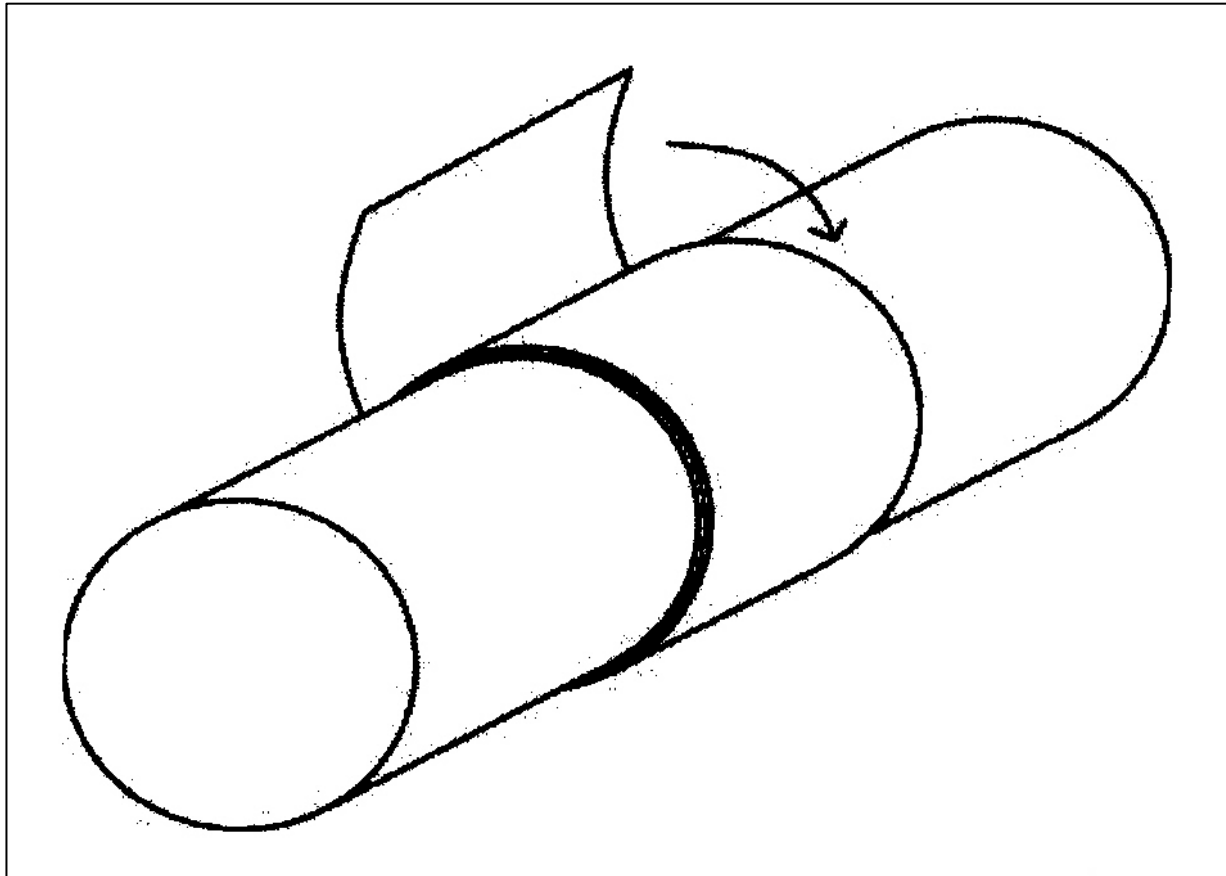


Composite Overwrap

Ductile Burst is Preceded by Outward Bulging



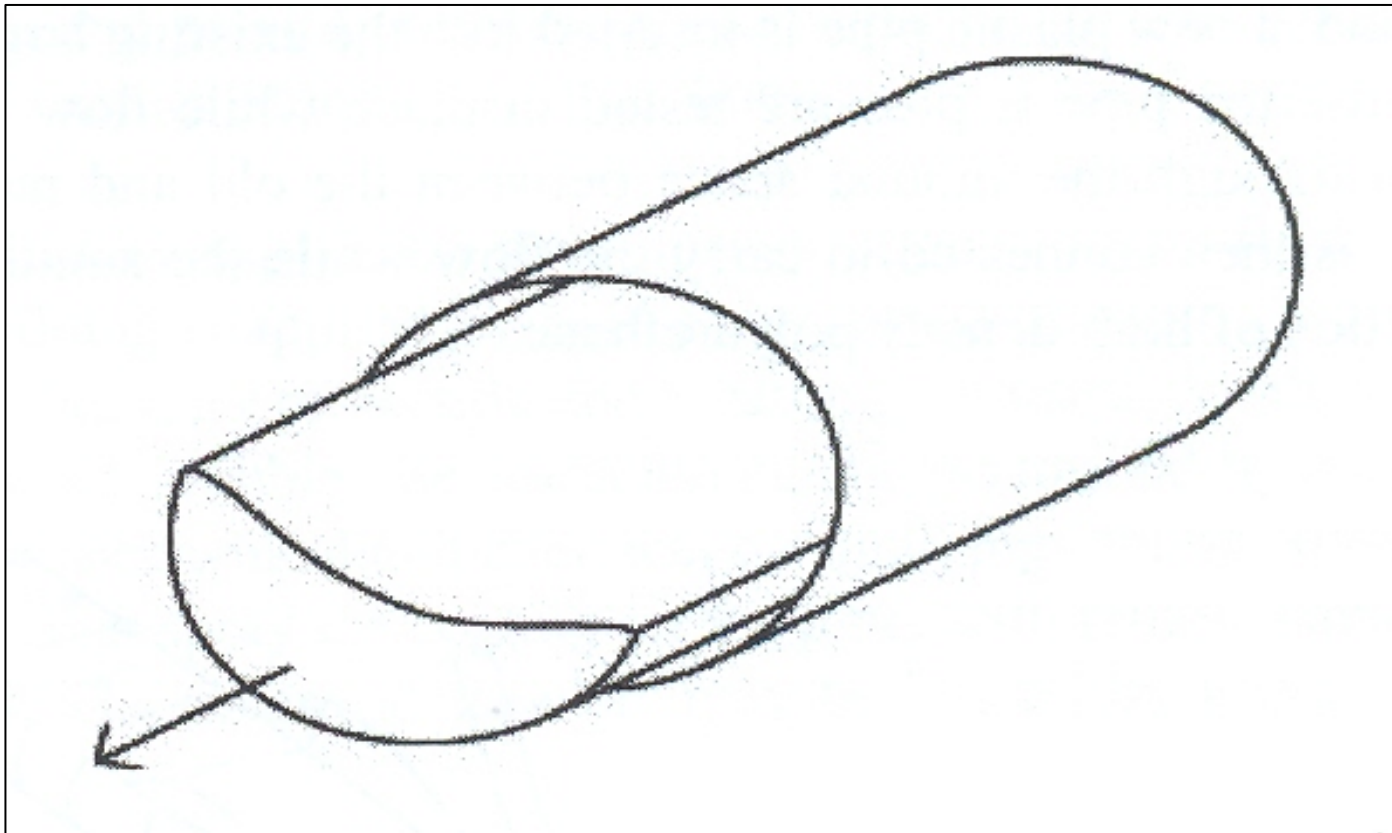
Composite Overwrap



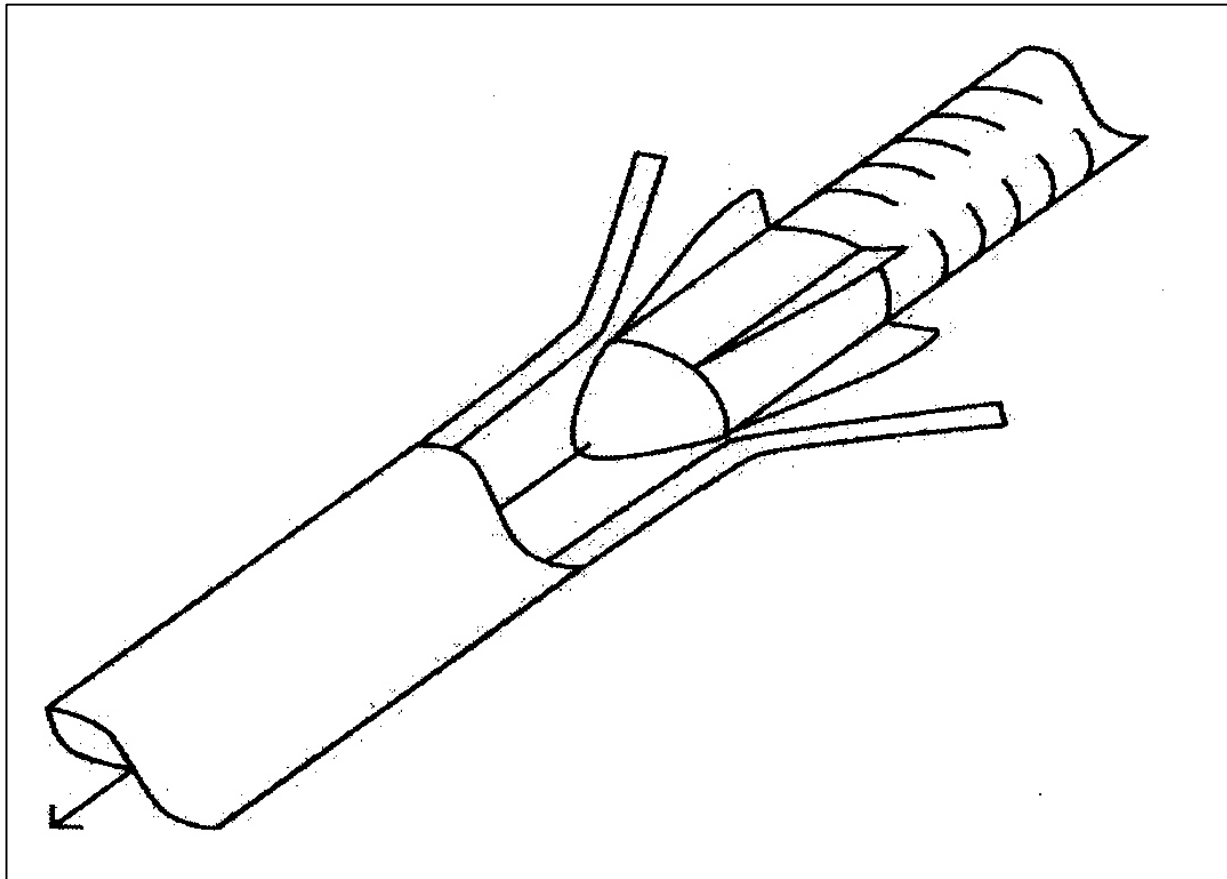
Buried Pipe Rehabilitation

- Repair buried pipe without the costly effort of digging, has resulted in the development of several trenchless repair techniques
- Accomplished by inserting a chemically resistant high-density polyethylene (HDPE) pipe inside the existing degraded pipe
- The HDPE liner is first deformed into a U-shape, and pulled through the existing pipe
- The U-shaped liner is then reformed to its circular shape, forming a pipe within a pipe
- The choice of the liner material is important

Buried Pipe Rehabilitation



Pipe Splitting With Polyethylene Pipe Follower



Brushed and Sprayed Lining and Coating

- A number of linings (covering the inner diameter) and coatings (covering the outer diameter) can be rolled, brushed or sprayed on the pipe to stop erosion, corrosion or abrasion of the pipe wall
- Linings are factory applied on new pipes or applied in the field.
- If the degradation is due to aggressive abrasion of the inner diameter, a ceramic reinforced epoxy liner may be used

Pipe Straightening

- Used to replace an accidentally bent pipe
- precautions:
- should not cause dent or gouge
- pipe cross section should not ovalize more than permitted in the construction code $< 8\%$
- pipe should not be wrinkled
- Cold straightening is possible if permitted by the construction code
- In critical service, if the straightened pipe contains a weld joint, the weld should be volumetrically examined.

Summary

- Pipeline rehabilitation and repair is essential for pipeline service
- Techniques depends on type of defects and the service of the line
- Cautions should be taken and risk have to be assessed before repair carried out.
- Repairing berried pipeline is costly and need cautions
- Pipe straitening is used to repair bend pipes