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Learning Resources for the course:

Steel Structure Inspector Course for PED INSPECTOR

This document covers only:

Competence unit no. CU-7 DESTRUCTIVE TESTING

Table of Contents

Introduction

Note. It is assumed that the teacher has in depth knowledge of the industry requirements for the topics discussed in this CU.

Reference document covering the course structure, see document D2.2
The content of this document covers deliverables for D4.1 and D4.2

The course consists of a number of CU´s. A CU is the smallest element in the education system that specifies Learning Outcomes, Skills and Competence. A CU can be delivered individually or it can be delivered in combinations with other CUs in order to cover a defined range of knowledge and competence.
The course will clarify the inspector's role in manufacturing where it begins well before welding starts, continues during the welding operation, involves action after welding is completed, and is finalized only when the results are properly reported.
The course will be work-based and follows the manufacturing process from the order is received until the welded product is ready for delivery. The inspector is responsible for producing documents that ensure traceability of the components and related manufacturing action throughout this process.

The activities in this course are work-based and follows a product from initial order and as it is being produced in the factory until it is ready for delivery. The manufacturing process has been divided in logical steps whereby the learning activity and learning content and tasks, are distributed according the status of the manufacturing process.
Activities in the course will be both planning activities as well as practical tasks to be carried out in the workshop together with the company mentor, or in a laboratory at the VET school.
The learning material will be distributed through the LMS (Learning Management System) system provided for this course.

CU 7 focus on Destructive testing. For most companies such test will be performed by outside sources and specialized companies. However it is important that the students have knowledge and competence from how to carry out such tests and also what should be prerequisite from the company´s point of view.

A. Teacher Guideline.

The activities in CU 7 covers destructive testing. The theoretical content should follow the IIW guideline, IAB-041r5-19/SV-00, module 2 item 2.1.
For the work-based training in the course, destructive testing will be related to developing WPS documentation. We foresee that the WPS should be developed from scratch, that means that a WPQR will be welded and that the required DT tests are carried out.
Also you have to require that qualified welders are used for the welding activities for the product being developed through this education. The required DT should also be discussed in this part of the course
The students should also understand the differences between the different DT methods and should be able to which tests to use for the welding procedure tests.
The documentation created in CU 4 can be used in this CU.
We assume that the students hav examples from their companies that can be used as examples.
Through the practical part of this CU the students should create some DT reports related to the product been produced.

One important topic is the equipment used for the activities. Go through and describe how to use the equipment correct and highlight also the advantages and disadvantages of it. Try to give practical examples as well or ask the students for examples from their companies.

B. Students Guideline

The activities in CU 7 covers destructive testing. The theoretical content should follow the IIW guideline, IAB-041r5-19/SV-00 module 2 item 2.1. Please read through this Guideline for theoretical content.
The DT activities are usually carried out in conjunction with development of WPS`s or in connection with creating or updating of welders certificate(s).
Most SME`s will outsource this activity to specialized test laboratories.
However it is a very important task that must be documented.

The documents developed in CU 4 can be used here.
Through the practical part of this CU you should create some DT reports related to the product been produced.

Under folder with “Resources and activities”. The material is available as pdf-files, word- and excel files, and video material (online at YouTube and as mp4 files stored in the learning management system). Please notice that the written assignments should be answered by using the word-files that are embedded into the description of the tasks. **You shall not use** the Office package installed on your own device.

C. Learning resources

Support resources from selected from the Internet.

Title	Producer	Reference	Language	No of pages	Copy-right

Learning resources developed in the project.

Title	Producer	Language	No of pages	Copyright
Destructive test	Matrai	English	8	No
Material test	Matrai	English	20	No

Video resources created for this CU

Title	Producer	Time	Reference	Language	Format	Copy-right
H8305CME	Matrai	0.42	Matrai	Hungarian	mov	No
H8306CME	Matrai	0.23	Matrai	Hungarian	mov	No
H8307CME	Matrai	0.33	Matrai	Hungarian	mov	No
H8308CME	Matrai	0.40	Matrai	Hungarian	mov	No
H8309CME	Matrai	0.42	Matrai	Hungarian	mov	No
H83010CME	Matrai	0.23	Matrai	Hungarian	mov	No
H83011CME	Matrai	0.42	Matrai	Hungarian	mov	No

D. Students tasks

In the company break a fillet weld and take a picture of the welded joint and give a comment of the joint and the fracture.

*Check the destructive test documents and give a report on the status.

1. Carry out destructive test where applicable for the welding

2. Define extent of test and report the test results

3. Create a repair report for destructive tests

E. Evaluation

1. Did you find this module relevant ?

* Yes
* No
* I don't know

2. Was it time enough for going through the material ?

* Yes
* No
* I do not know

3. Was the resources relevant for this module ?

* Yes
* No
* I do not know

F. Appendix.

Learning resources developed for this CU.

CU7
Destructive test

1. Destructive test

For destructive examination parts of the workpiece and the weld must be prepared. Test pieces are taken from the weld and machined. In some cases, these test pieces are further prepared by making a local reduced section, a making notch in the surface or polishing the surface.

One special way is breaking the test piece under normal temperature.

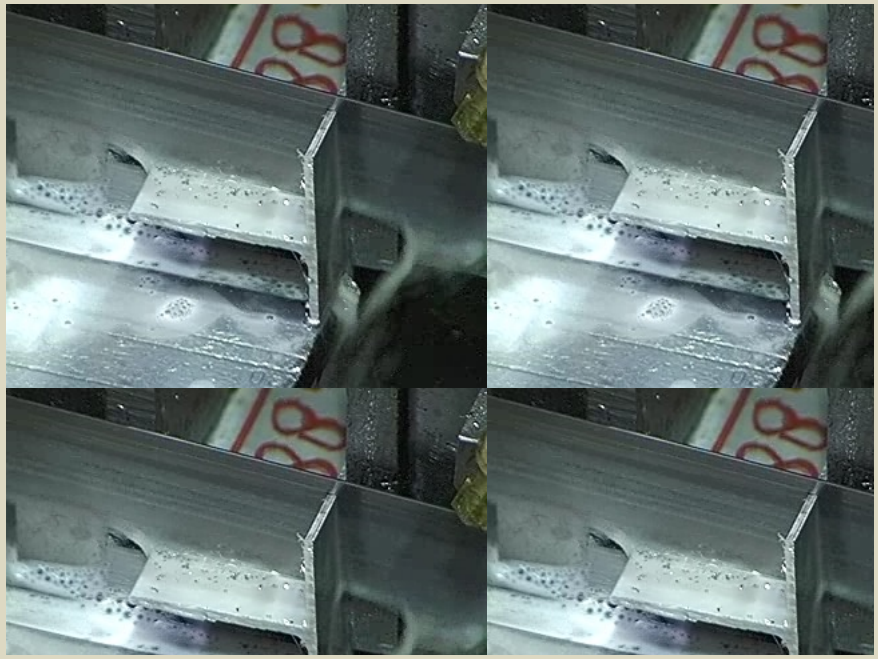
1.1 Fracture test

The fracture test is mainly applied for fillet welds. It is a quick test that shows whether the fillet weld has a good penetraion and whether there is lack of fusion. The judgement requires expertise (EN1320)

1.2. Macro test

A careful preparation is necessary for producing a macro of a weld cross section. After the necessary saqing and polishing, etchant is applied to the weld. After some time, you will see that the weld and the deviations become such as:

- Porosity
- Lack fusion
- Insufficient penetration

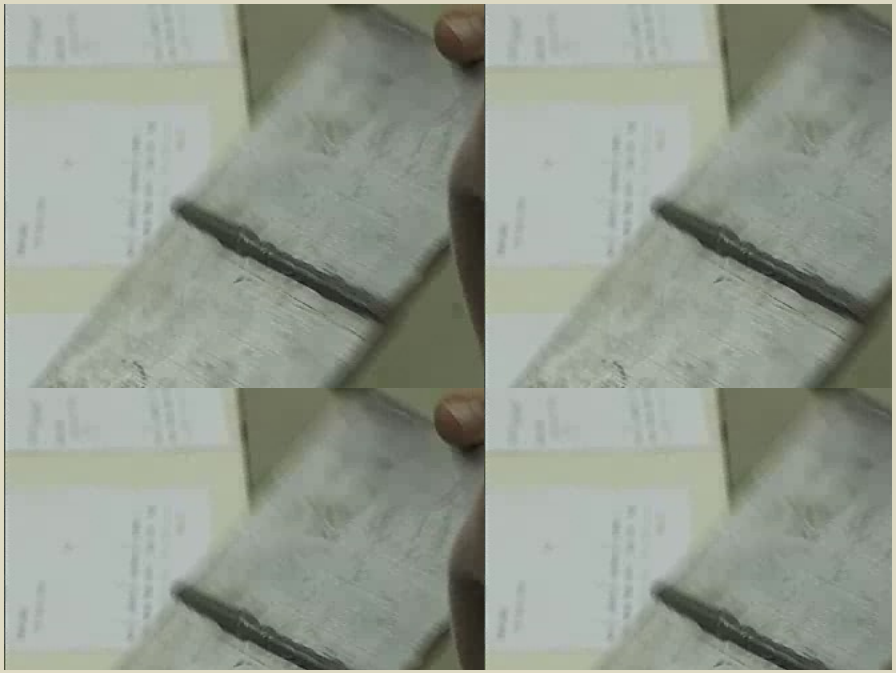


1.3 Hardness test

This test measures the ductility of the joint. Ductility gets lower if the hardness of the weld is too high. The process is called, Vickers hardness test. The unit of hardness given by the test is known as the Vickers Pyramid Number (HV). The pyramid refers to the diamond used in the test. The maximum hardness of a weld for a determined material is prescribed and is given in „HV" value. The locations of the weld to be tested are precisely prescribed too.

1.4 Transverse tensile test

For a butt weld the fusion between weld and base material can be tested and measured with a transverse tensile test. The dimensions of the test piece are taken accurately before testing. Finally the load at fracture and the location of the fracture are registered.



1.5 Bend test

The bend test is carried out on a correctly prepared test piece taken from a butt weld. It gives mainly information about the existence of lack of fusion defects in the weld.

1.6 Notch fracture test

This test gives information about the ductility of the welded joint. The test specimen can be taken from different parts of the test piece, it can be taken from the weld and the heat affected zone. In this testpiece a notch is milled, which will or will not be the initiation of the fracture.
This examination is done in different temperatures.

Material tests

- the materials testing deals with:
  - the composition and structure of materials
  - investigating the properties of materials
  - investigating changes during manufacture
  - detecting possible defects in the finished product

Grouping of material tests

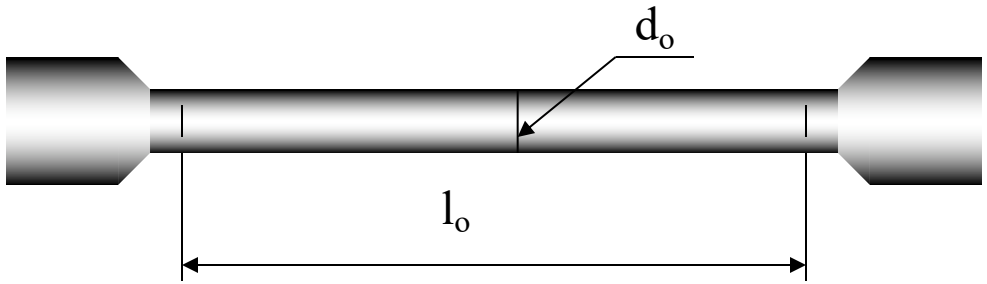
- according to the change in substance
  - destructive
  - non-destructive
    - detection of external defects
    - detection of internal defects

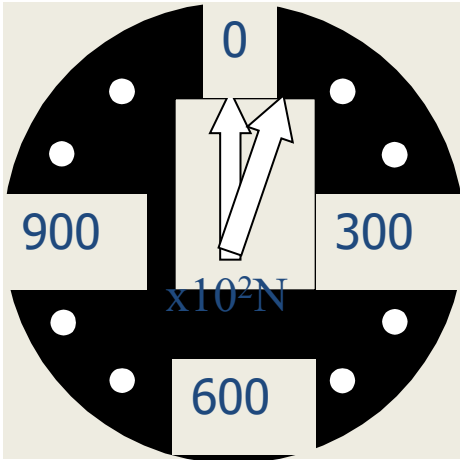
tensile testing

- purpose: to determine the strength and ductility properties of the material
- necessary for the test:
  - to the rupture machine
  - a standard test specimen

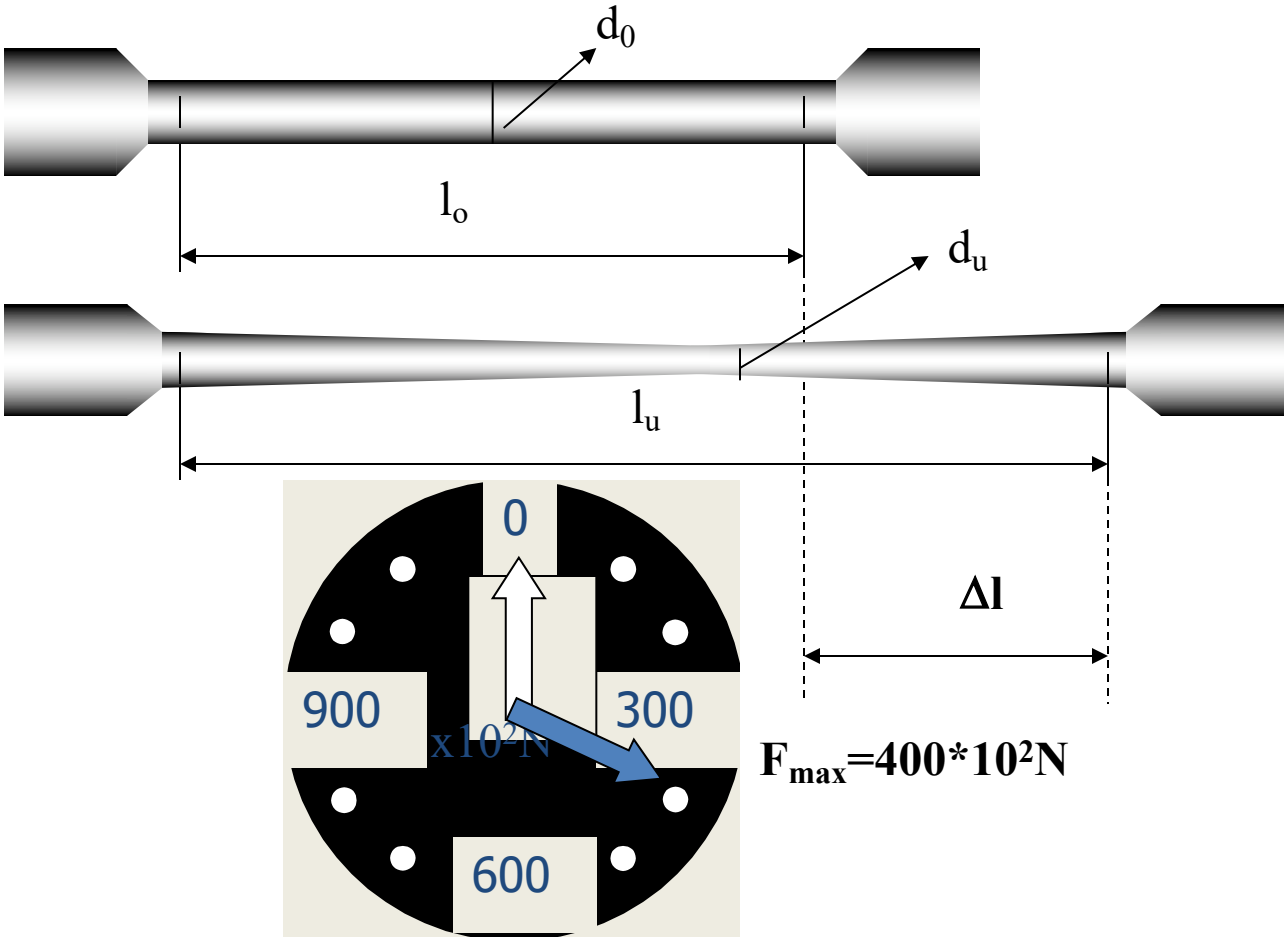
tensile testing

trial body

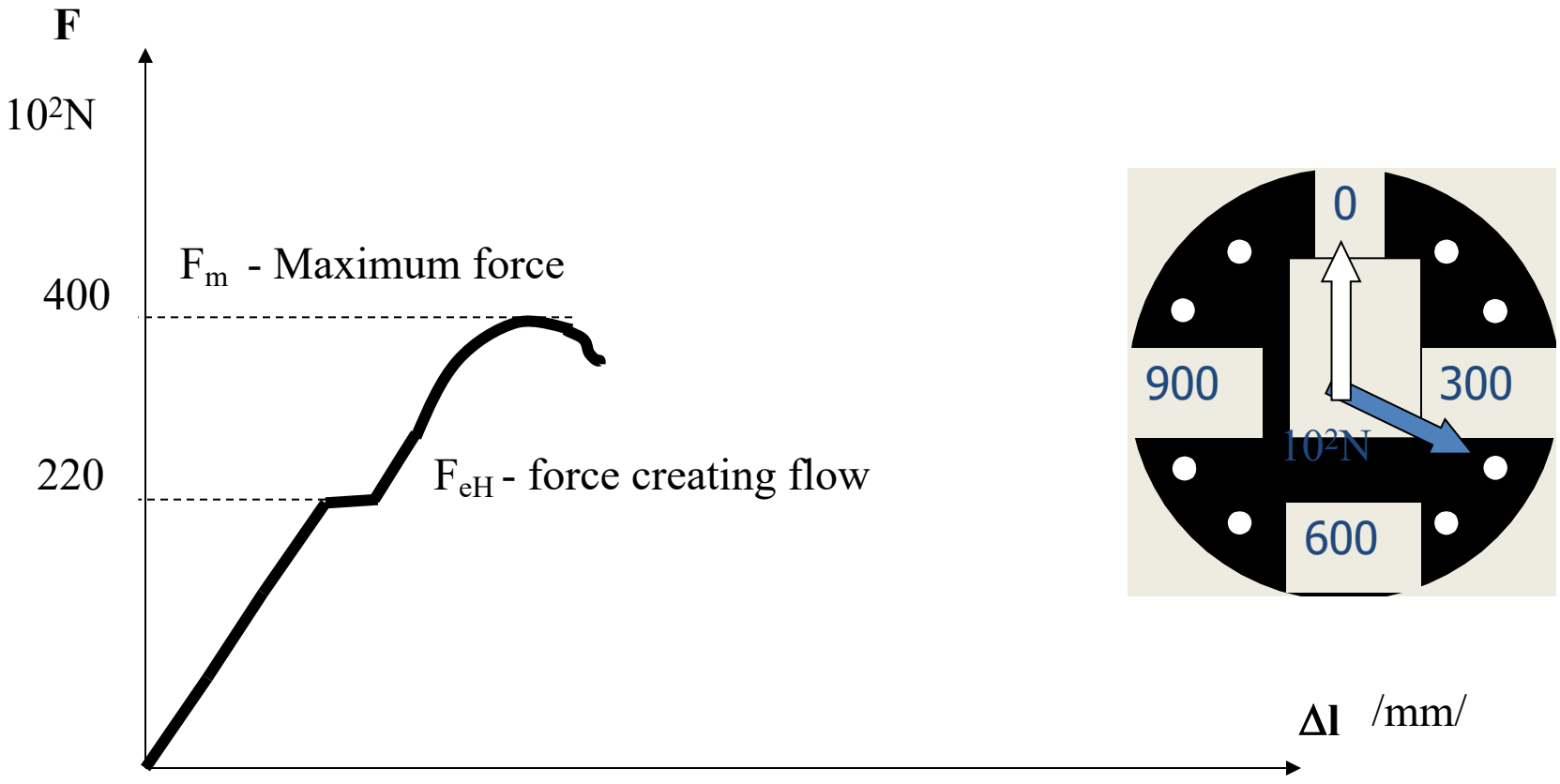




tensile testing



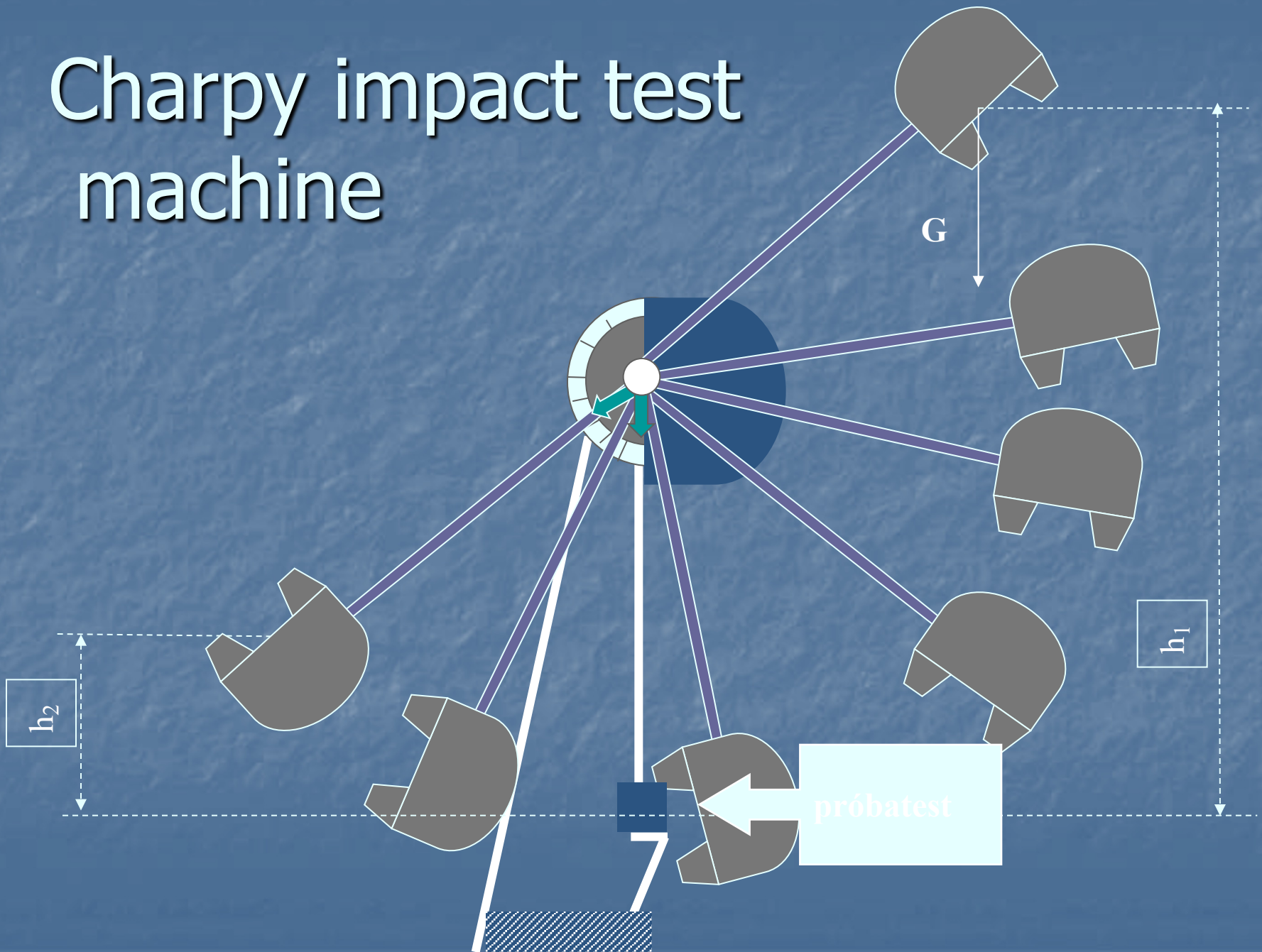
soft steel tensile diagram



impact test

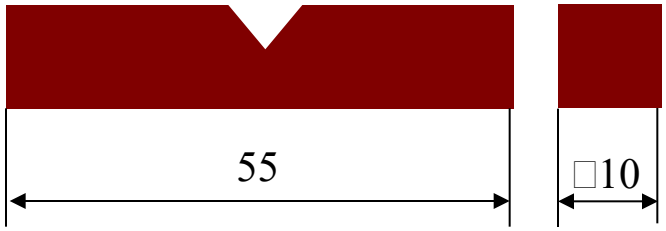
- purpose: to determine the impact behavior of the material of components subjected to dynamic stress

Charpy impact test machine



impact test

- the test body
- notch may be:
  - V
  - U



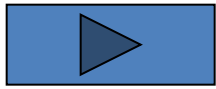
- Impact work:

hammer weight

$$KV\ /KU,/= G/\ h_1\text{-}h_2\ /\ \ (J)$$

hardness measurement

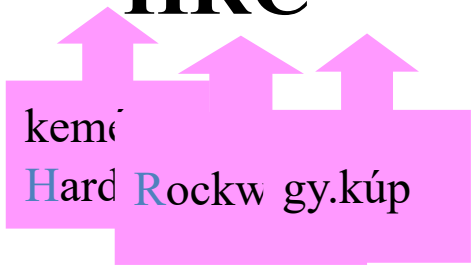
- the concept of hardness:
  - the resistance of a material to penetration by a foreign object
- The resistance of a material to a foreign object may be:
  - by method of loading:
    - ✓ static
    - ✓ dynamic
  - by measuring deformation:
    - ✓ impression, surface defining
    - ✓ depth of indentation



puncture hardness measurement
Rockwell hardness test

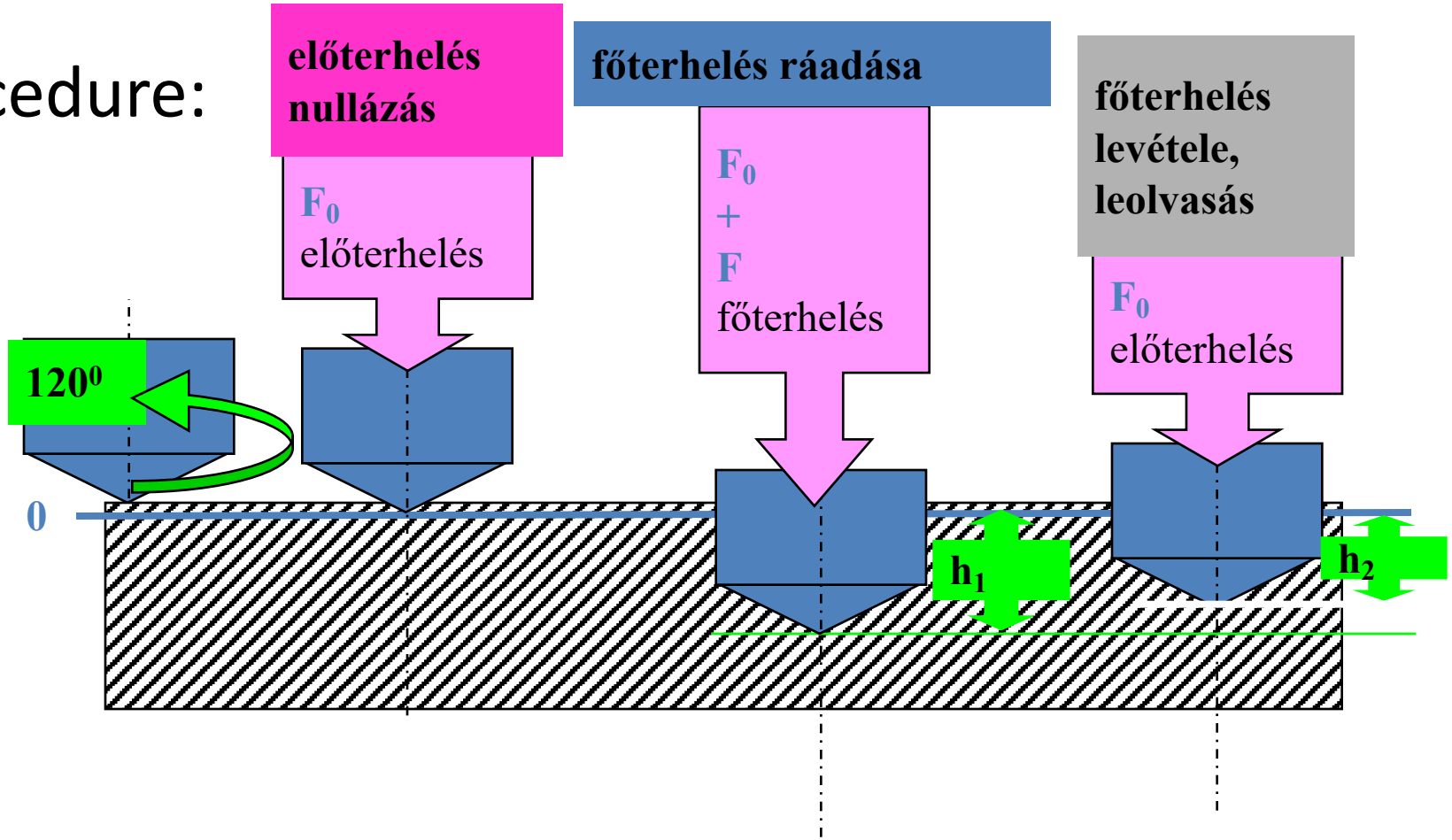
- **tool:**
  - 1200 tip angle diamond cone /HRA, HRC, HRN/
  - 1.59 mm diameter hardened steel ball /HRB, HRT/
- the depth of the indentation indicates the hardness, directly readable from the dial gauge

pl. 60 HRC



puncture hardness measurement Rockwell hardness test

- Procedure:

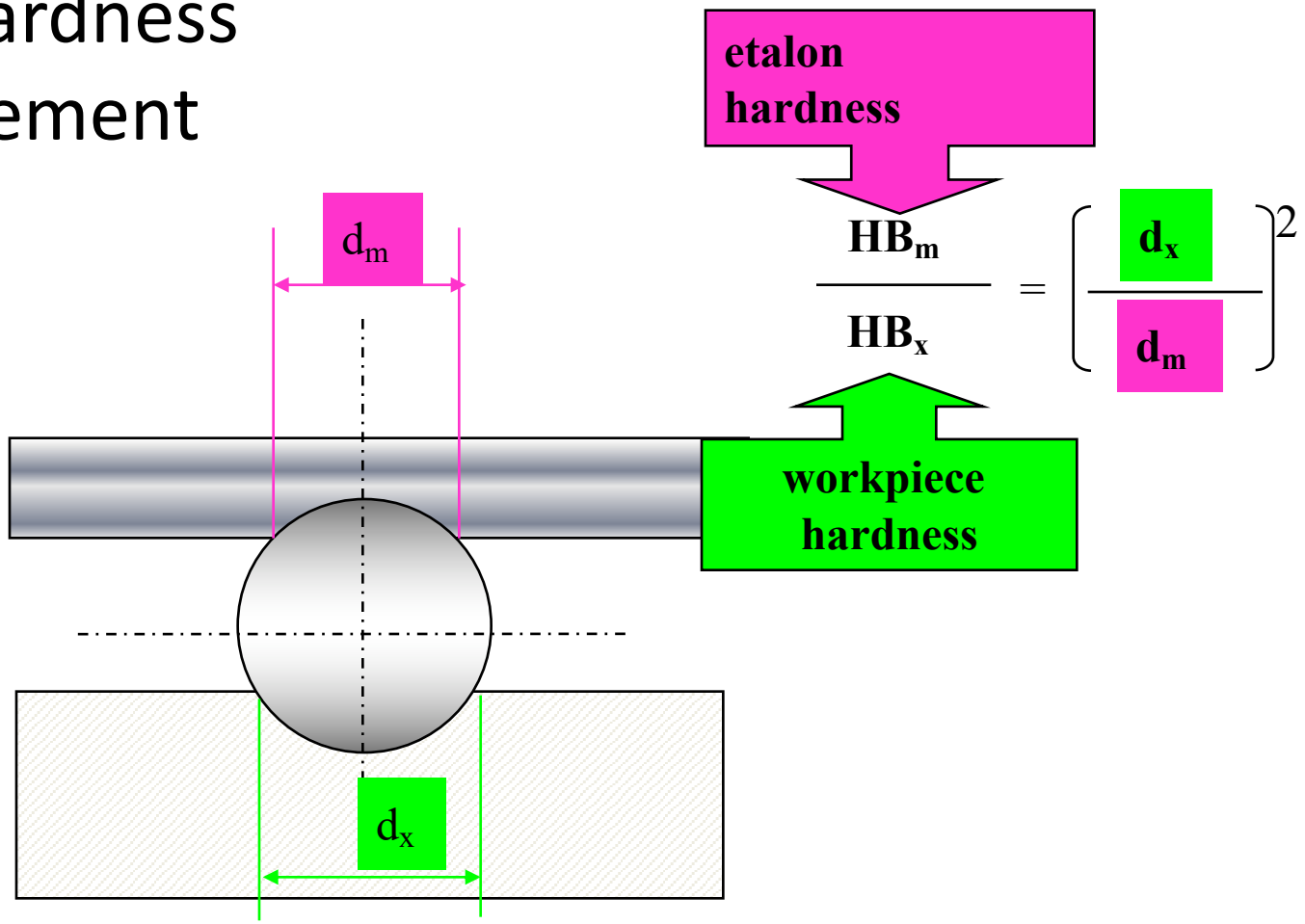


dynamic hardness measurement with a boring tool

- POLDI hardness measurement procedure:
- preparation of the workpiece surface
- insertion of the standard
- dynamic load force /hitting with a hammer/.
- measurement of the impression on the workpiece /dx/, on the etalon /dm/
- determination of the hardness from the attached table

dynamic hardness measurement with a boring tool

- POLDI hardness measurement



dynamic hardness measurement with a boring tool

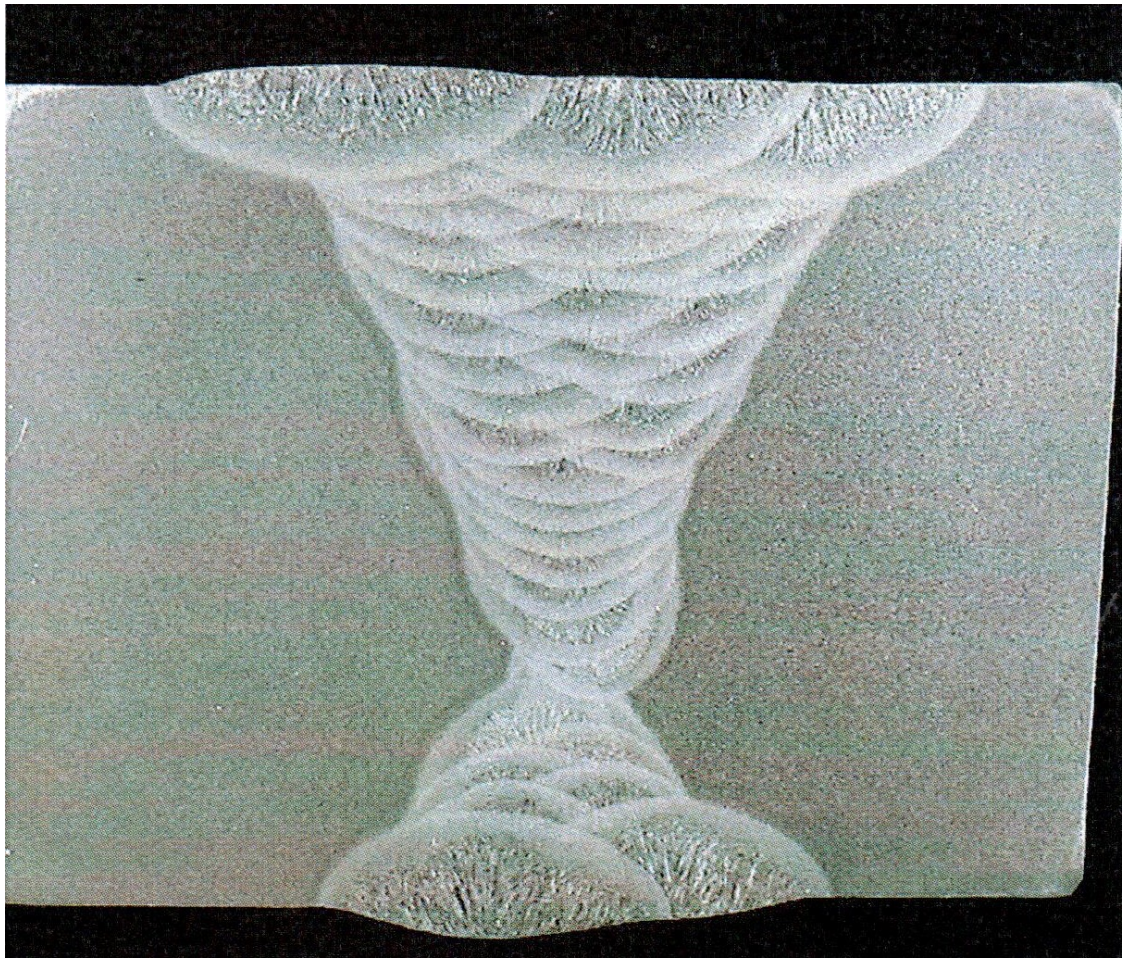
- application:

– thin materials, not suitable for testing materials harder than hardened steel balls
– Brinell hardness measuring hand tool
– suitable for on-site measurements, testing large workpieces

metallographic tests

- aim: to study tissue structure
- types:
  - macroscopic
    - ✓ macroscopic - naked eye or with hand magnifying glass /e.g. inclusions, fissures, mesh fineness/
  - microscopic
    - ✓ with optical equipment with a metal microscope at 100-1000x magnification
    - ✓ grinding, etching, magnified image examination/ e.g. grain size, phase ratio, fabric structure, etc./

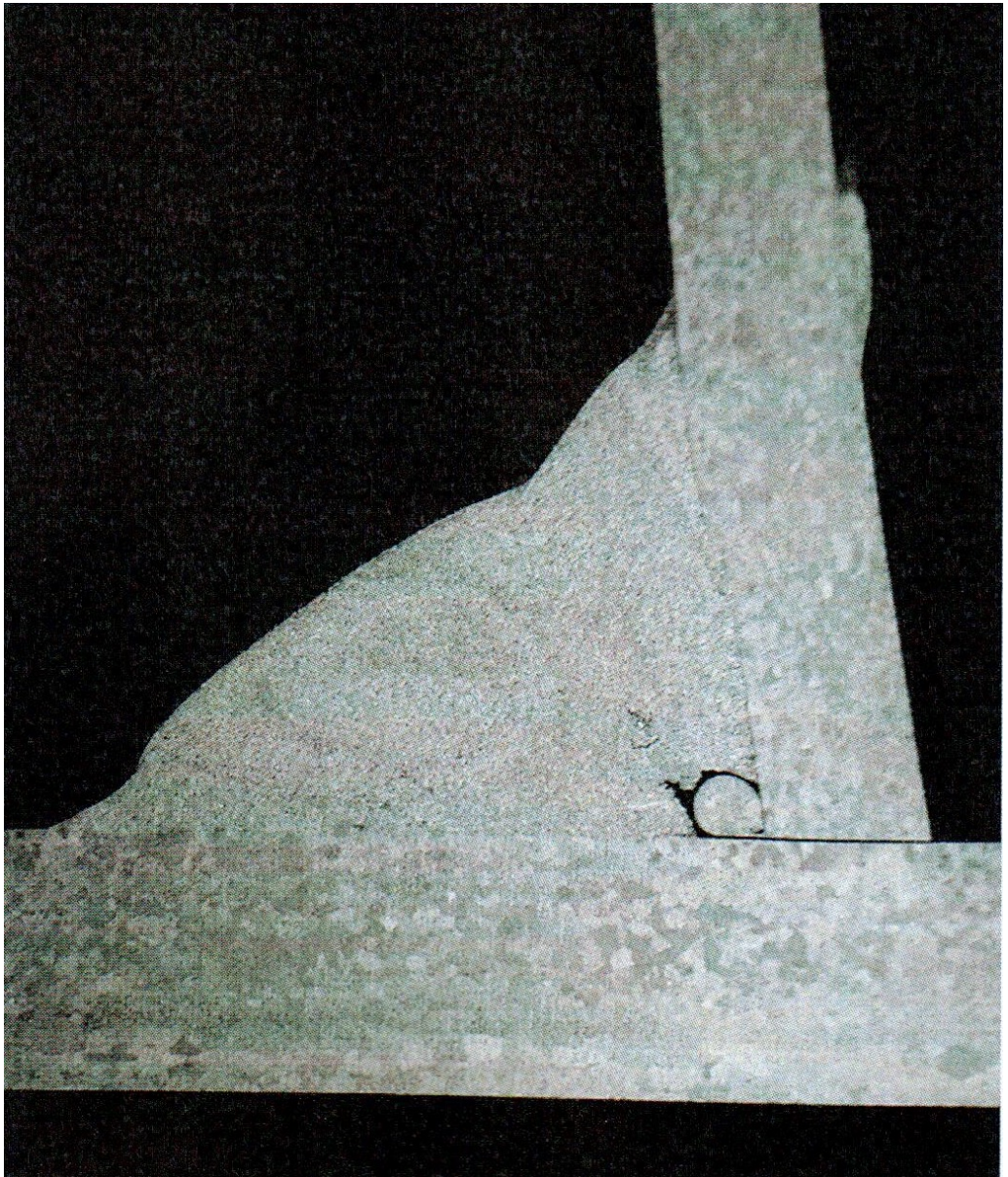
metallographic examination



In macroscopic and microscopic examinations, many "interesting" defective tissue structures are encountered, and in the following we will look at some of these phenomena.

A good quality multi row carbon steel 135 process multi row butt welded steel tube.

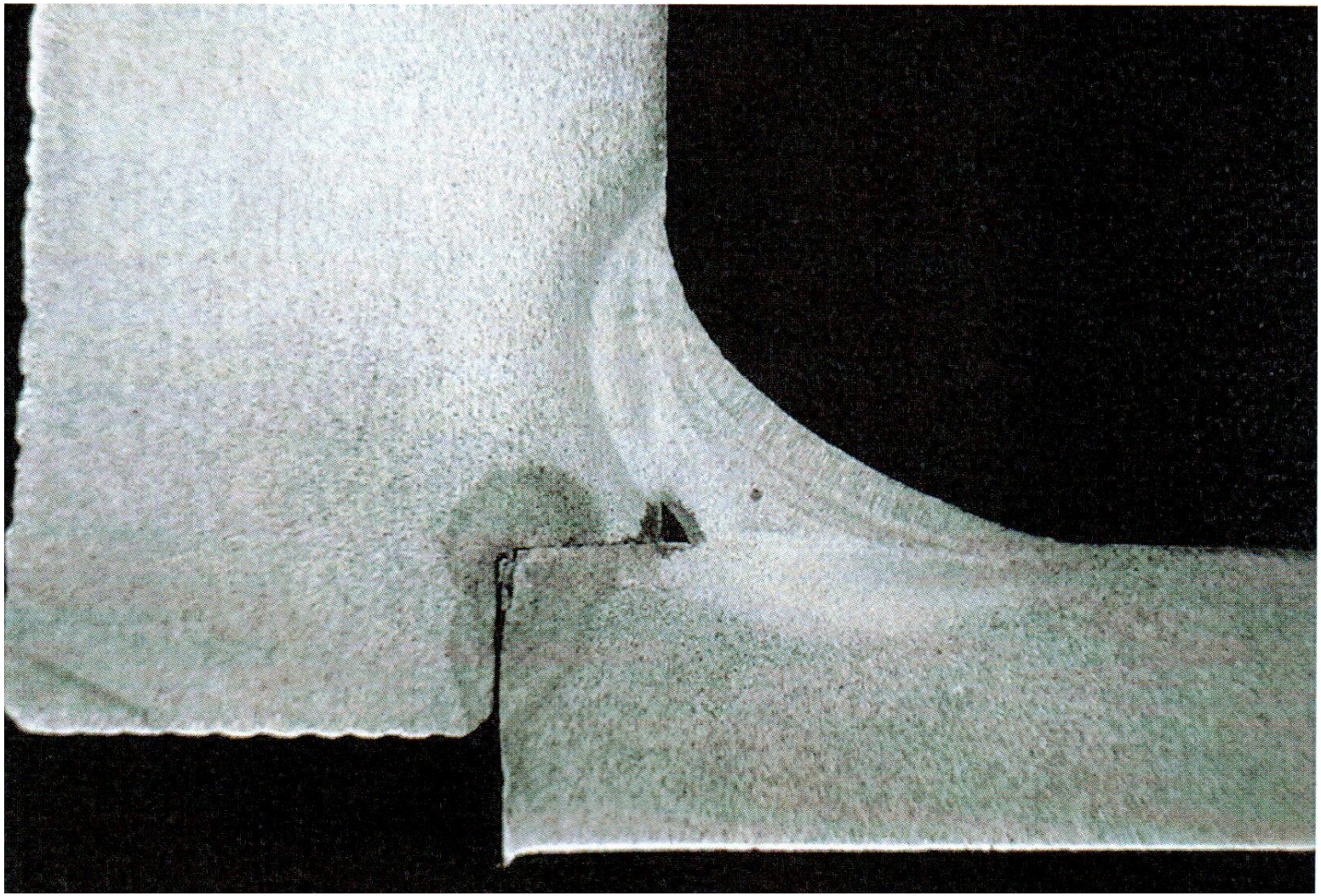
metallographic examination



Deviations are more common in corner welds than in butt welds. Experience shows that 90% of poor quality corner welds contain fusion or fusing defects.

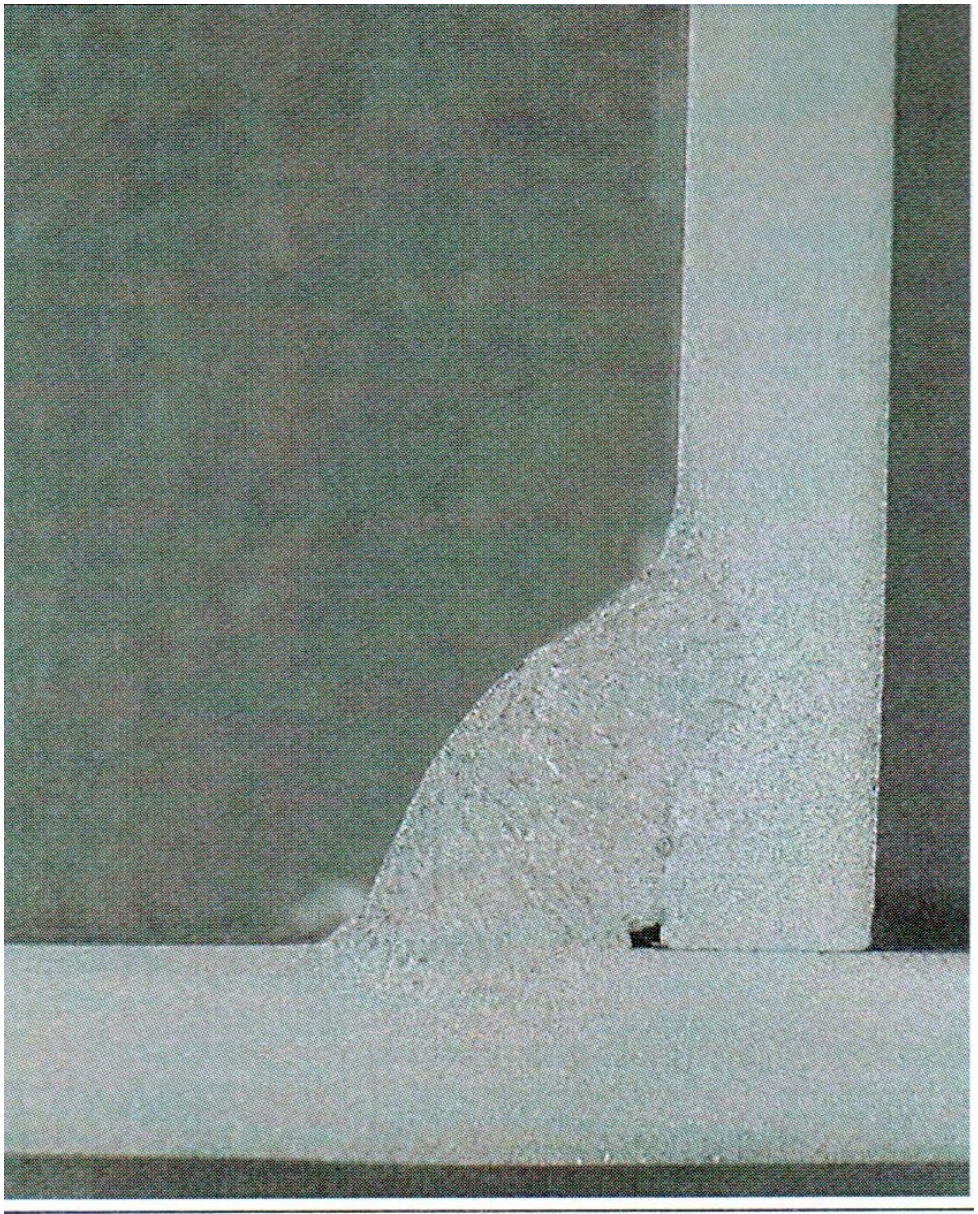
The joint is made using a 135 gauge welding process.

metallographic examination



Insufficient melting and gas porosity.
The joint is made by welding process 141.

metallographic examination



Basic material S235JR 1.2
Welding position PB
Welding procedure 135
Material size t1=t2= 3mm

Evaluation:Melting of base material correct, transition between base material and weld is correct, weld size is correct, root melting is incomplete, overall not appropriate!

Reason for rejection: according to EN ISO 5817 B - incomplete fusion, not allowed (code 402 according to ISO 6520-1)