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Fluxys Technical Specifications

-NDT-

Technical Specifications – Part 7: Inspection of welding work

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In case of questions or comments, please contact the Process Manager.

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CONTENTS

Artikel 7.00 Introduction: Standards applicable to the inspection of welding work

The inspection of welding work and the overall organisation associated with such work (quality system, welding procedure qualifications, qualification of welders and personnel, documentation, etc.) must meet the requirements set out in:

- Document 4.90.000/9024: Technical Specification for Non-Destructive Testing
- Norm EN 12732: Gas supply systems – Welding steel pipe work – Functional requirements.
- Royal Decree of 19 March 2017 – Royal Decree on safety measures for the establishment and operation of facilities for the transmission of gaseous and other products by pipelines
- Ministerial Decree of 24 September 2021 – Ministerial Decree approving the Technical Code on the safety measures applying to the design and construction of facilities for transmission by pipelines.

Technical Specifications Part 7 is based on EN 12732 supplemented by specific requirements.

In the event of discrepancies between the Technical Specifications and EN 12732, the Technical Specifications shall always take precedence.

Artikel 7.01 Supervision and inspection of welding activities

The supervision and assessment of welding activities shall be carried out by the designated authorised inspection organisation (AIO) and the owner.

The liability of the AIO is limited to its own interventions and decisions.

The NDT contractor is responsible for non-destructive testing (NDT). Depending on the requirements of the Particular Specification, the NDT contractor shall be appointed by the owner or the contractor.

Each technique described in this document shall be performed within an accredited quality assurance system for the relevant scope in accordance with EN ISO/IEC 17020.

Procedures used for carrying out NDT shall have been submitted in advance to the AIO and owner for review and approval.

The NDT inspectors shall be EN ISO 9712-certified.

Artikel 7.02 Type and frequency of inspections

7.02.01 Facilities built with a design pressure ≤ 16 bar

For facilities built with a design pressure ≤ 16 bar, the inspections from the table 'Minimum extent of non-destructive testing' in EN 12732 are supplemented with the following provisions:

If an inspected weld is unacceptable, then the two adjoining (n+1 and n-1) welds which have not been inspected yet and which are welded by the same welder(s) shall be inspected. In the event of unacceptability of one or two of the adjoining (n+1 and n-1) welds, the inspection shall be extended to the following two (n+2 and n-2) welds (done by the same welder(s)), which have not yet been inspected.

Extensions following non-acceptable results do not contribute to the testing percentages in Table "Minimum extent of non-destructive testing" of EN 12732.

All welds shall undergo additional 100% visual testing. This testing shall be in accordance with EN ISO 17637.

Prior to the welding of branches, ultrasonic and magnetic testing shall be carried out on a 100mm zone along and around the location of the weld to ensure the absence of rolling defects.

The percentage of non-destructive testing for facilities built with a design pressure ≤ 16 bar is 100% for:

- facilities erected in or attached to constructions such as bridges, viaducts and tunnels;
- crossings or intersections of streams, rivers, canals and lakes;
- intersections of railway tracks, regional and provincial roads and other major transport arteries;
- intersections by directional drilling or casing pipes;
- pipelines in areas with a high housing density (identified in the regional plan as a residential area) or less than 20 m from residential buildings and constructions.

The increase to 100% non-destructive testing for the above locations does not contribute to the testing percentages in Table 'Minimum extent of non-destructive testing' of EN 12732.

Golden welds:

- Prior ultrasonic and magnetic testing shall be carried out on a 100mm zone along and around the location of the weld to ensure the absence of rolling defects in the case of:
  - welding on old pipeline sections (≤ 1975).
- Golden butt welds shall be tested by radiography. For pipes or fittings, this inspection shall be extended by:
  - an ultrasonic weld inspection for t ≥ 8mm;
  - a magnetic inspection in all other cases.
- Golden fillet welds and branches shall only be magnetically tested.

Inspection using a penetrant instead of a magnetic technique may be allowed by the owner in exceptional cases.

Depending on the defects that occur, the owner may unilaterally require additional inspections on all completed and all future welds. The contractor shall bear the full cost of additional inspections that yield unacceptable results.

7.02.02 Facilities built with a design pressure > 16 bar

For facilities built with a design pressure > 16 bar, the inspections from the table 'Minimum extent of non-destructive testing' in EN 12732 are supplemented with the following provisions:

All welds shall undergo additional 100% visual testing. This testing shall be in accordance with EN ISO 17637.

Fillet welds and branches shall undergo 100% magnetic testing.

Prior to the welding of branches, ultrasonic and magnetic testing shall be carried out on a 100mm zone along and around the location of the weld to ensure the absence of rolling defects.

For pipeline construction:

Manually welded construction:

All welds shall be subjected to a 100% radiographic inspection.

In addition to the radiographic testing, 100% ultrasonic testing shall be performed for t ≥ 8mm and 100% magnetic testing for t < 8mm in the following cases:

- welds in directional drillings;

- 100 in-line welds, spread over the first six kilometres, for steel alloys with a minimum specified yield strength ≥ 415 N/mm² and a nominal external diameter ≥ 406.4mm;
- all clamped connection welds and repair welds involving steel grades with a minimum specified yield strength ≥ 415 N/mm² and a nominal external diameter ≥ 406.4mm. The supplementary inspection of these connection welds and repair welds shall not be added to the supplementary inspection of welds within the first six kilometres.

Automatically or mechanized welded construction:

The installation is always subjected to a 100% (semi) automatic ultrasonic control with continuous registration of the data and the results over the length of the weld. Consisting of either TOFD+Pulse Echo or Phased Array.

The applied technique shall guarantee the detection of both longitudinal and transverse defects.

In addition, 20 welds in line within the first six km are inspected by radiography.

For station construction:

Butt welds shall always be subjected to a 100% radiographic inspection.

For pipes or fittings made of a steel grade with a minimum specified yield strength ≥ 415 N/mm² and a nominal external diameter ≥ 406.4mm, radiographic inspection shall be supplemented by:

- 100% ultrasonic testing for t ≥ 8mm;
- 100% magnetic testing for t < 8mm.

Golden welds:

- Prior to this: a zone of 100 mm along and around the welding spot should be ultrasonically and magnetically examined for the absence of rolling defects in
  - welding on old pipe parts (≤ 1975).
  - if deemed necessary

- Golden butt welds shall always undergo radiographic testing. For pipes or fittings, this inspection shall be supplemented by:
  - an ultrasonic weld inspection for t ≥8mm;
  - a magnetic inspection in all other cases.

  If it is impossible to respect the minimum distance between the longitudinal or spiral weld when making tie-ins, then additional non-destructive testing shall be carried out on the

longitudinal or spiral welds for the absence of any detectable weld imperfection. This over a distance of at least 200mm left and right to the circumferential weld. This involves:

- an ultrasonic weld inspection where t ≥8mm;
- a magnetic inspection in all other cases.

- Golden fillet welds and branches shall only undergo magnetic testing.

Inspection using a penetrant instead of a magnetic technique may be allowed by the owner in exceptional cases.

Depending on the defects that occur, the owner may unilaterally require additional inspections on all completed welds and all welds that have yet to be completed. The contractor shall bear the full cost of additional inspections that yield unacceptable results.

Artikel 7.03 Execution of non-destructive testing

The non-destructive testing shall be conducted in accordance with 4.90.000/9027: Technical Specification for Non-Destructive Testing.

(Semi)automated ultrasonic testing, TOFD+PE or PA, shall be qualified and performed in accordance with 4.90.000/00126: Qualification and execution of automated ultrasonic examination.

Artikel 7.04 Time of inspection

The weld joint shall be inspected after any heat treatment, before the resistance and leak testing and before the joint is painted or coated.

The visual inspection shall precede the other non-destructive tests. In the event of an non-acceptable visual inspection, the other non-destructive tests shall not be conducted.

The inspection shall take place during normal working hours. If, at the contractor's request, the inspection takes place outside normal working hours, then the additional costs related to the monitoring and inspection shall be borne by the contractor.

The required waiting time for ultrasonic testing when using cellulosic electrodes is 24 hours. This waiting time does not apply in the following circumstances:

- if, for the hot pass, the filler runs and the capping run a low-hydrogen (max. H5) welding process has been applied;
- for pipes or fittings made of a steel grade with a minimum specified yield strength ≤ 245 N/mm².

As a rule, the non-destructive testing shall be carried out on the same day as, or one day after, completion of the weld(s) insofar as the day's welding production is sufficient for the normal daily output of the NDT contractor.

Crawlers shall not be used on pipeline sections that are still being welded, even if the usual deadlines are compromised as a result.

Artikel 7.05 Communication of the results

7.05.01 General remarks

The NDT contractor shall communicate to its client the results of the non-destructive testing carried out on a given day the latest by 12am the next working day. At the contractor's request and with the owner's consent, the NDT contractor may also provide the results directly to the contractor, provided that its client is the owner.

7.05.02 Connections of installations by golden weld(s)

Visual inspection, ultrasonic testing and magnetic or penetrant testing:

After carrying out the inspections, the NDT contractor shall communicate the test results within the contractually defined time frame. These results shall be communicated as set out in 4.90.000/9024: Technical Specification for Non-Destructive Testing.

The visual inspection shall precede the other non-destructive tests. In the event of an non-acceptable visual inspection, the other non-destructive tests shall not be conducted.

The NDT contractor shall mark the correct repair zone(s) on the weld to be repaired.

Radiographic inspection:

After producing the radiographs, the NDT contractor shall communicate the test results within the period contractually agreed with the owner. These results shall be communicated as set out in 4.90.000/9024: Technical Specification for Non-Destructive Testing.

The NDT contractor shall mark the correct repair zone(s) on the weld to be repaired.

Artikel 7.06 Acceptance criteria for natural gas installations

7.06.01 Overview by NDT technique

	Pipeline construction	Junctions	Station construction	Hot tap Repair sleeve
Code	1.xx.xxx 3.xx.xxx (5.xx.xxx)	1.xx.xxx 3.xx.xxx (5.xx.xxx)	2.xx.xxx 4.xx.xxx	1.xx.xxx 2.xx.xxx 3.xx.xxx 4.xx.xxx
RT – t < 7mm	API 1104	API 1104	API 1104	
RT – t ≥ 7mm	EPRG Tier 1	API 1104	API 1104	
UT	EN ISO 11666 lev.2 + TS 4.90.000/9024	EN ISO 11666 lev.2 + TS 4.90.000/9024	EN ISO 11666 lev.2 + TS 4.90.000/9024	EN ISO 11666 lev.2 + TS 4.90.000/9024
MT	API 1104	API 1104	API 1104	EN ISO 23278 lev. 2X
PT	API 1104	API 1104	API 1104	EN ISO 23277 lev. 2X
VT – t < 7mm*	API 1104	API 1104	API 1104	EN ISO 5817:2014 lev.B + EN 12732 Annex H
VT – t ≥ 7mm*	EPRG Tier 1	API 1104	API 1104	EN ISO 5817:2014 lev.B + EN 12732 Annex H

* For visual inspections, the maximum value for excess weld metal is 3mm, regardless of the wall thickness. The excess weld metal shall be uniform and the transition from the weld metal to the base material shall be smooth (see ASME B31.8 and EN 1708-1), with the angle between the cap and the base material measuring at least 120°.

Table 1: Acceptance criteria by type of facility and by NDT technique

7.06.02 Arc strikes and craters

Arc strikes and craters of mass clamps shall be avoided as much as possible. Each arc strike or crater of a mass clamp shall be inspected. This inspection shall consist of at least:

- visual inspection before filing;
- filing of the zone;
- visual inspection after filing and confirmation that the indication is no longer visible;
- MT inspection after filing; and
- measurements, where the depth after filing is limited to ≤ 0.5mm with reference to the surrounding base material.

The remaining wall thickness after filing should always be greater than the design wall thickness.

Copper inclusions and microcracks are unacceptable. Additional inspections may be required depending on the location, dimensions and observations. Such additional inspections may

consist of hardness measurements following initial evaluation after polishing and chemical etching of the relevant zone.

If no separate zone can be distinguished from the base material after etching, then that zone is acceptable. If a separate zone can be distinguished, repeat the previous steps if the design wall thickness is still guaranteed. If, after additional filing, polishing and chemical etching, a separate zone can ultimately be distinguished, then check the hardness by making hardness measurements in that zone and assessing these values based on the flowchart -par. 7.07.02

- Expanding to two new locations is not possible in this case.
- The dimensions of the inspected zone and the min. spacing in between measuring points can limit the number of hardness measurements.
- In the flow chart Figure 1 - Option A – par. 7.07.02 – 250HV is replaced by 300HV.

Arc strikes and craters shall be removed by cutting if not acceptable.

Artikel 7.07 Facilities for hydrogen applications

For facilities up to a DP of 84 bar intended for the transport of hydrogen and the transport of hydrogen blended with natural gas, the following additional requirements shall apply.

Unless stated otherwise in this section, the other provisions of these Technical Specifications shall apply.

7.07.01 Acceptance criteria: overview by NDT technique

	Pipeline construction	Junctions	Station construction	Hot tap Repair sleeve
Code	1.xx.xxx 3.xx.xxx (5.xx.xxx)	1.xx.xxx 3.xx.xxx (5.xx.xxx)	2.xx.xxx 4.xx.xxx	1.xx.xxx 2.xx.xxx 3.xx.xxx 4.xx.xxx
RT – t < 7mm	API 1104	API 1104	API 1104	
RT – t ≥ 7mm	API 1104	API 1104	API 1104	
UT	EN ISO 11666 lev.2 + TS 4.90.000/9024	EN ISO 11666 lev.2 + TS 4.90.000/9024	EN ISO 11666 lev.2 + TS 4.90.000/9024	EN ISO 11666 lev.2 + TS 4.90.000/9024
MT	API 1104	API 1104	API 1104	EN ISO 23278 lev. 2X
PT	API 1104	API 1104	API 1104	EN ISO 23277 lev. 2X
VT – t < 7mm*	API 1104	API 1104	API 1104	EN ISO 5817:2014 lev.B + EN 12732 Annex H
VT – t ≥ 7mm*	API 1104	API 1104	API 1104	EN ISO 5817:2014 lev.B + EN 12732 Annex H
* For visual inspections, the maximum value for excess weld metal is 3mm, regardless of the wall thickness. The excess weld metal shall be uniform and the transition from the weld metal to the base material shall be smooth (see ASME B31.8 and EN 1708-1), with the angle between the cap and the base material measuring at least 120°.				

Table 2: Acceptance criteria by type of facility and by NDT technique

7.07.02 Mobile hardness testing with U(ltrasonic) C(ontact) I(mpedance) method

Only UCI-type HV10 (98N) probes may be used.

Percentage of welds to be subjected to hardness tests:

Type of Facility	Test Percentage
Station construction	20% of welds
Pipeline construction: connection welds and clamped welds	10% of welds
Pipeline construction: line welds	10% of welds1
Repairs	100% of repair welds with one (of the) repair zone(s) per weld

Table 3: Frequency of hardness tests

The specified percentages and expansion rules shall be applied to the same type of weld (line weld, connection weld, etc.) and to welds having the same welding process/Welding Procedure Specification (WPS) or the same sequence of welding processes/WPSs. The selected welds shall be physically sufficiently spread out and ensure a representative sampling of all variables including the welders. The AIO shall select the welds to be hardness tested, in consultation with the owner.

In the event that a hardness-tested weld (n) does not comply, the next weld before (n-1) and after (n+1) this weld (n) shall be hardness tested. If one of the two welds (n+1 or n-1) is unsatisfactory, the testing shall be expanded to welds n+2 and n-2. If both welds (n+2 and n-2) are acceptable, the percentages in Table 2 shall be re-applied. If the HT result for at least one of the welds (n+2 or n-2) is unacceptable, the testing shall be expanded to 100% HT in both directions and on new weld production according the respective WPS too. The 100% shall be maintained in both directions until two consecutive welds with an acceptable HT result are observed.

Expansions after unacceptable HT results shall not contribute to the percentages specified in Table 2.

Depending on the diameter, one or more locations shall be selected per weld for carrying out hardness tests:

[1] Switching from 10% to 5% HT is possible for automated (robotic)or mechanised welded line welds if the HT results are acceptable based on the percentage of hardness-tested welds within the first 200 line welds. If, after the reduction, an unacceptable weld based on the HT is detected and weld 'n+1' or 'n-1' is also unacceptable, then 10% of the next 200 line welds are hardness tested again.

Number of locations per weld :

Diameter	# locations per weld	Position of location(s)	Comment
Ø ≤ DN150	1 location	at 1h30	-
DN150 < Ø ≤ DN300	2 locations	EITHER at 3h and 6h OR at 12h and 9h	2 options to be applied alternately
DN300 < Ø	3 locations	EITHER at 3h, 6h and 12h OR at 9h, 6h and 12h	2 options to be applied alternately

Table 4: Number of locations per weld

Each location shall consist of five zones:

1. BM1 – Base Material 1
2. HAZ1 – Heat-Affected Zone 1
3. Weld
4. HAZ2 – Heat-Affected Zone 2
5. BM2 – Base Material 2

Each individual hardness measurement shall be performed randomly in the respective zone.

The hardness value per zone shall be calculated based on at least 10 hardness measurements – Option A – (Figure 1) or at least 9 hardness measurements – Option B – (**Error! Reference source not found.**) per zone:

For welds on newbuild installations:

The HAZ is visible from polishing (min. 240 grit) and additional chemical etching (Figure 1 – Option A).

For existing welds:

The HAZ is visible from:

- polishing (min. 240 grit) and additional chemical etching (Figure 1 – Option A);
- or polishing only (min. 240 grit) (Figure 2 – Option B), if for practical reasons Option A cannot be implemented.

The method according to Option A is the preferred method to make hardness measurements. The method according to Option B is only allowed with the consent of the owner.

Determine the acceptability per zone according to the flowcharts below for Option A (Figure 1) and Option B (**Error! Reference source not found.**).

Carry out the hardness tests – Options A and B – in accordance with the provisions of document 4.90.000/9024: Technical Specification for Non-Destructive Testing.

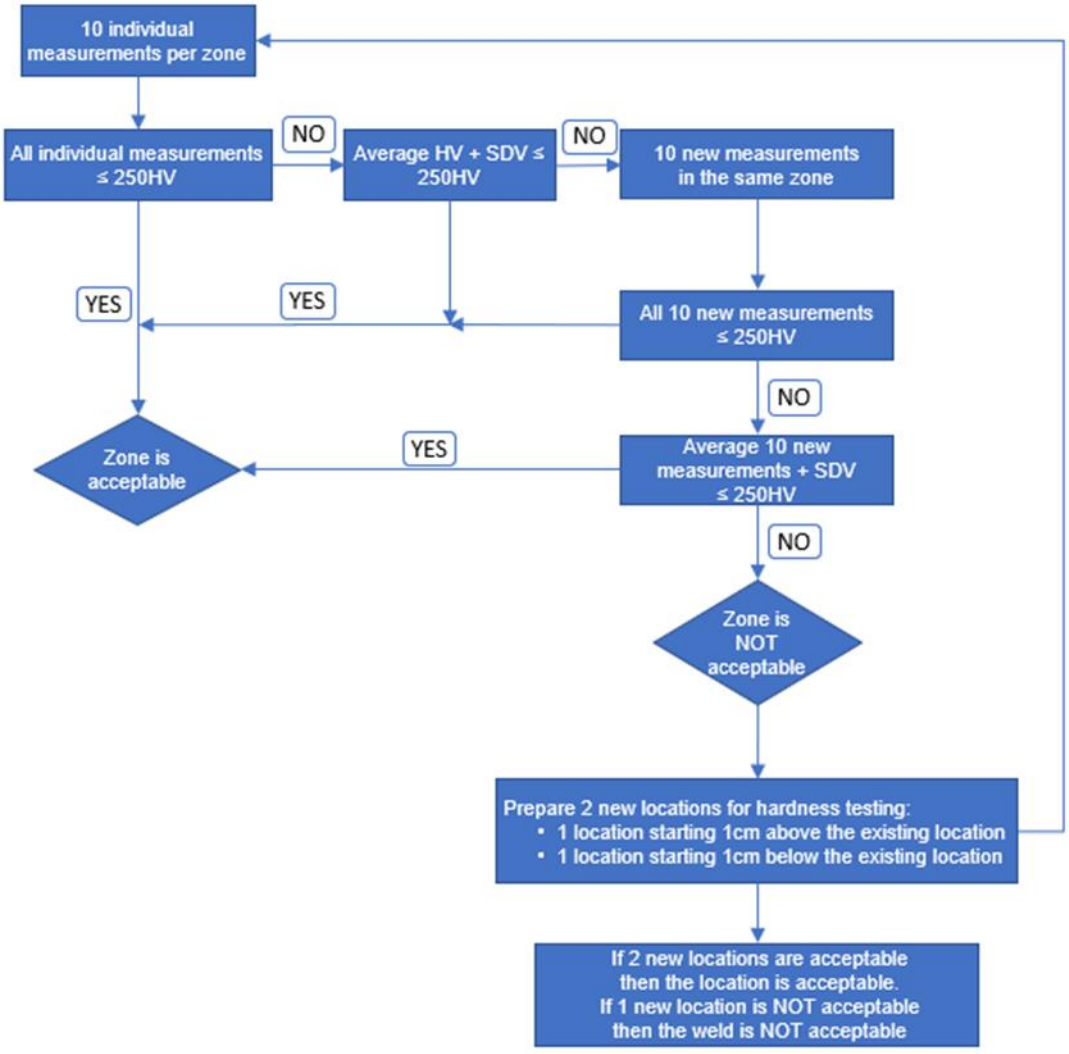

Figure 1: Determining hardness value and acceptability per zone: Option A[2]

[2] SDV means standard deviation

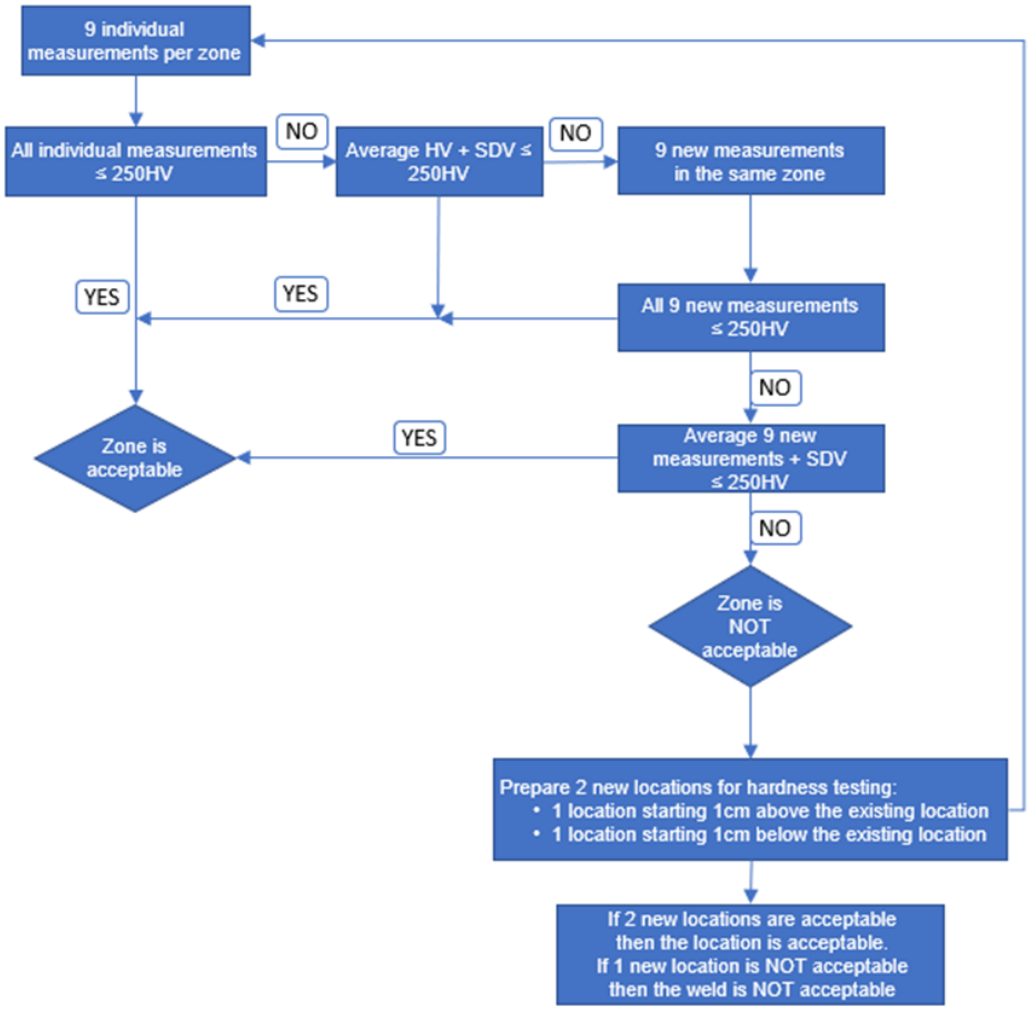

Figure 2: Determining hardness value and acceptability per zone: Option B[3]

[3] SDV means standard deviation

7.07.03 Arc strikes and craters in hydrogen applications

See section 7.06.02. In the case of hydrogen facilities, the zone must also be polished and chemically etched after filing. If after final etching (see section 7.06.02), no separate zone can be distinguished from the base material, then that zone is acceptable. If a separate zone can be distinguished, then check the hardness by making hardness measurements in that zone and assessing these values based on the flowchart **Error! Reference source not found.**

- Expanding to two new locations is not possible in this case.
- The dimensions of the inspected zone and the min. spacing in between measuring points can limit the number of hardness measurements.

Arc strikes and craters shall be removed by cutting if not acceptable.

Artikel 7.08 Recording of test results

The inspection report for NDT shall mention at least the following:

- reference procedure and revision;
- the facility's code number;
- wall thickness and material;
- surface condition;
- testing date;
- operator's name and qualification;
- weld number and acceptability, stating the defect type, length, location and orientation.

The inspection report shall futher meet the requirements set out in 4.90.000/9024: Technical Specification for Non-Destructive Testing.

Artikel 7.09 NDT on repairs

All repairs (after grinding and/or re-welding) shall be re-inspected using the same NDT technique(s) as the original weld. The re-welded (repaired) zone shall be considered, and not the original defectlength.

In addition, ultrasonic ($t \geq 8mm$) or magnetic ($t < 8mm$) testing shall be carried out on repairs between steel grades with a minimum specified yield strength ≥ 415 N/mm^2 and a nominal external diameter ≥ 406.4mm.

Non-destructive testing shall be performed on the repaired zone plus at least 100mm extra on both sides of the repaired zone.

The owner or AIO may require that the non-destructive testing be expanded to the entire weld.

Artikel 7.10 Distribution of inspection costs

The additional costs relating to supervision and inspection shall be borne by the contractor if these activities take place at its request and/or outside normal working hours.

Inspections of defective welds shall be charged to the contractor and shall be calculated proportionally based on the total inspection costs for the work concerned, i.e.:

$$Costs\ charged\ to\ the\ contractor\ = \frac{Total\ inspection\ costs\ x\ \%\ of\ defective\ welds}{100\%\ +\ \%\ of\ defective\ welds}$$

Formula 1 Distribution of inspection costs

Additional inspections due to expansion rules in case of defective welds shall be charged to the contractor.

Additional inspections to these described in this document and requested by the owner with unacceptable results shall be charged to the contractor.

The costs associated with destructive testing of production welds shall be borne by the owner. If the results of the destructive testing do not meet the requirements set out in the Technical Specifications, those costs shall be borne by the contractor.

NDT carried out at the contractor's request in addition to the minimum inspections required by the owner shall be be borne by the contractor.

Artikel 7.11 Reference documents

7.11.01 List of documents referred to

Royal Decree of 19 March 2017 – Royal Decree on safety measures for the establishment and operation of facilities for the transmission of gaseous and other products by pipelines.

Ministerial Decree of 24 September 2021 – Ministerial Decree approving the Technical Code on the safety measures applying to the design and construction of facilities for transmission by pipelines.

4.90.000/9027: Technical Specification for Non-Destructive Testing.

4.90.000/00126: Qualification and execution of automated ultrasonic examination.

4.90.000/00051: Technical Specification part 6: Welding.

7.11.02 List of standards referred to in Part 7

EN

EN 12732: Gas infrastructure – Welding steel pipework – Functional requirements

EN ISO 9712: Non-destructive testing – Qualification and certification of NDT personnel

EN 1708-1: Welding – Basic welded joint details in steel – Part 1: Pressurized components

EN ISO 17637: Non-destructive testing of welds – Visual testing of fusion-welded joints

EN ISO/IEC 17020: Conformity assessment – Requirements for the operation of various types of bodies performing inspection

EN ISO 11666: Non-destructive testing of welds – Ultrasonic testing – Acceptance levels

EN ISO 23278: Non-destructive testing of welds – Magnetic particle testing – Acceptance levels

EN ISO 23277: Non-destructive testing of welds – Penetrant testing – Acceptance levels

EN ISO 5817:2014: Welding – Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) – Quality levels for imperfections

API

API 1104: Welding of Pipelines and Related Facilities

ASME

ASME B31.8: Gas Transmission and Distribution Piping Systems

ASME B31.12: Hydrogen Piping and Pipelines