

GUIDED WAVES METHOD (GW)

This document refers to some tables and numbers found inside the tables and text of the UNI EN ISO 9712 standard so as to clarify, for the GW method:

- 1) minimum training requirements
- 2) industrial experience
- 3) some conditions relevant to examination procedures

Syllabus for the GW Method – Levels 1,2 and 3

Letters T and P followed by a number indicate, respectively, the theory section and the practical section of the course expressed in hours.

Contents	Level 1 (Above ground steel pipework)	Duration (hours)
G.1 Introduction to NDT terms and history	Tasks of NDT personnel NDT history GW history GW terms	T 1.0
G.2 Physical principles of the method and associated knowledge	Revision of basic concepts of mathematics Theory of propagation of waves Reflection, attenuation and dispersion effects Property of guided waves inside pipes Various types of GW methods Torsional, longitudinal and flexural Transmission and reception of GW Piezoelectric effect Magnetostriction EMAT Transduction Types of transducers Transducer array configuration Directionality Frequency limits Dead zone and near field Influence of transduction and frequency over inspection GW focusing Factors influencing the selection of test parameters. Influence of pipe geometry and configuration	T 8.0
G.3 Knowledge of product and method capability	Design of pipes and various defects relating to manufacturing and servicing of pipes. Implementation of inspection techniques depending on the product and discontinuities Influence of geometry and structure	T. 4.5
G.4 Instrumentation	Various probes and software. Emitter-receiver unit Transducers and wiring Echo-pulse mode operations A-scan C-scan Automatic system control and calibration Coupling control Distance calibration Width calibration	T.2.5 P. 5.0
G.5 Information before the test	Written instruction (prepared by a level 2 or 3 technician): Objectives Requirements	T 1.5
G.6 Inspection	Data collection and identification of symmetrical characteristics Methodological approach for data analysis using GW information in echo-pulse mode Identification of welds and flanges Distance Amplitude Correction (DAC) Range and sensitivity settings Use of welds and flanges for setting DAC curves Data collection and identification of non-symmetrical characteristics Identification of welds, take-off pipes and different types of supports Influence of inner and outer coatings and of pipe condition on the analysis in echo-pulse mode	T 10.0 P 35.0

Contents	Level 1 (Above ground steel pipework)	Duration (hours)
	Signal attenuation and typical results Echo information Analysis of echoes present in the results obtained in echo-pulse mode	
G.7 Interpretation and relation	Characteristics that are not directly visible Defects Assessment thresholds Influence of frequency on defect identification Influence of focusing on defect identification Evaluation of defect seriousness	T 4.5 P 7.0
G.8 Assessment	Not applicable	
G.9 Quality	Personnel qualification (in accordance with UNI EN ISO 9712) Check of instruments	T 1.0
G.10 Development	Not applicable	
Total duration		T 33.0 P 47.0

Contents	Level 2 (Above ground steel pipework)	Duration (hours)
G.1 Introduction to NDT terms and history	Overview of level 1 Terms and definitions	T 0.5
G.2 Physical principles of the method and associated knowledge	Overview of level 1 Various types of GW (thorough knowledge) Transduction Factors influencing selection of test parameters Sensitivity to rigidity changes Effects caused by characteristic geometry Position of transducing system	T 4.0
G.3 Knowledge of product and method capability	Same as level 1 plus: Implementation of inspection techniques used to check areas near or inside the axial extension of other characteristics Various types of supports Pipe structural integrity – rules and standards applicable to a specific sector	T 4.0
G.4 Instrumentation	Same as level 1 plus: Advanced transducing systems Hardware and software requirements for test parameter optimization C-scan (thorough knowledge)	T 0.5 P 2.0
G.5 Information before the test	Requirements and contents of instructions, procedures and standards Drafting of a written instruction	T 3.0
G.6 Inspection	Same as level 1 plus: Advanced DAC Spurious data (thorough knowledge) Signal phase Inspection below supports Effect of temperature over inspection	T 8.0 P 10.0
G.7 Interpretation and relation	Same as level 1 plus: Evaluation of defect seriousness (thorough knowledge) Identification of defects near other characteristics	T 1.0 P 4.0
G.8 Assessment	Assessment and confirmation of test results Assessment: Assessment criteria in conformity with standards and procedures	T 1.5
G.9 Quality	Personnel qualification (in accordance with ISO 9712) Check of instruments Written instruction Documentation traceability	T 1.0
G.10 Development	General information	T 0.5
Total duration		T 24.0 P 16.0

Contents	Level 2 (Buried pipes)	Duration (hours)
G.1 Introduction to NDT terms and history	Overview of level 2 (Above ground steel pipework) Terms and definitions	T 0.5
G.2 Physical principles of the method and associated knowledge	Transduction Factors influencing the selection of test parameters. Influence of pipe geometry and configuration Attenuation due to viscoelastic material Attenuation due to the material around the pipe (earth, sand, etc..) Attenuation variation with frequency Effect of entrance into solid material (inside wall, earth etc..) Effect on GW test results due to covering and ground conditions	T 8.0
G.3 Knowledge of product and method capability	Same as level 2 (Above ground steel pipework) plus: Various characteristics and defects present in road crossings and buried pipes Implementation of inspection methods depending on the product and discontinuities which are the target of inspection Influence of geometry and structure on GW	T 2.0
G.4 Instrumentation	Same as level 2 (Above ground steel pipework) plus: Advanced transducing systems for road crossings and buried pipes Transduction optimization during inspection of road crossings and buried pipes	T 3.0 P 2.0
G.5 Information before the test	Requirements and contents of instructions, procedures and standards. Drafting of a written instruction for road crossings and buried pipes.	T 4.0
G.6 Inspection	Same as level 2 (Above ground steel pipework) plus: Advanced DAC for road crossings and buried pipes. Spurious data (thorough knowledge) Strategies to be used to select the test position	T 6.0 P 6.0
G.7 Interpretation and relation	Same as level 2 (Above ground steel pipework) plus: Identification of defects inside inaccessible areas with highly attenuating materials and/or inside solid materials (earth, sand, etc..)	T 2.0 P 4.0
G.8 Assessment	Assessment and confirmation of test results Assessment: Criteria in accordance with standards and procedures	T 1.5
G.9 Quality	Personnel qualification (in accordance with ISO 9712) Check of instruments Written instruction Documentation traceability	T 0.5
G.10 Development	General information	T 0.5
Total duration		T 28.0 P 12.0

Contents	Level 2 (Pipes)	Duration (hours)
G.1 Introduction to NDT terms and history	Overview of level 2 (Above ground steel pipework) Terms and definitions	T 0.5
G.2 Physical principles of the method and associated knowledge	Transduction Factors influencing the selection of test parameters. Attenuation due to broad-spread corrosion and/or deposits Attenuation variation with frequency Effect due to diaphragms	T 7.0
G.3 Knowledge of product and method capability	Same as level 2 (Above ground steel pipework) plus: Various characteristics and defects present in pipelines (heat exchangers and boiler pipes) Implementation of inspection methods depending on the product and discontinuities which are the target of inspection Influence of geometry and structure on GW	T 2.5
G.4 Instrumentation	Same as level 2 (Above ground steel pipework) plus: Advanced transducing systems for pipe inspection Transduction optimization during inspection of pipes Effect of frequency and frequency band on the results	T 3.0 P 1.5
G.5 Information before the test	Requirements and contents of instructions, procedures and standards. Preparation of a written instruction concerning pipelines	T 0.5
G.6	Same as level 2 (Above ground steel pipework) plus:	T 2.5

Contents	Level 2 (Pipes)	Duration (hours)
Inspection	Spurious data (thorough knowledge) Multiple echoes Signal phase	P 1.5
G.7 Interpretation and relation	Same as level 2 (Above ground steel pipework) plus: Evaluation of defect seriousness	T 1.5 P 2.0
G.8 Assessment	Assessment and confirmation of test results Assessment: Criteria in accordance with standards and procedures	T 0.5
G.9 Quality	Personnel qualification (in accordance with ISO 9712) Check of instruments Written instruction Documentation traceability	T 0.5
G.10 Development	General information	T 0.5
Total duration		T 19.0 P 5.0

Contents	Level 3 (Pipes and pipelines)	Duration (hours)
G.1 Introduction to NDT terms and history	Terms and definitions History of the method	T 2.0
G.2 Physical principles of the method and associated knowledge	Same as level 2 (Pipes and pipelines) plus: Revision of basic concepts of mathematics Advanced theory of propagation of waves Dispersion and compensation factors Material property effects Multilayer systems Attenuation due to viscoelastic materials and the material around the pipe (parameters influencing GW and mathematical predictions) Sensitivity to rigidity changes Property of guided waves in cylindrical and toroidal structures Various types of GW methods Torsional, longitudinal and flexural GW modes in curves Transduction Advanced transducer array configuration Selection of transduction parameters	T 10.0
G.3 Knowledge of product and method capability	Same as level 2 (Pipes and pipelines) plus: Manufacture of Pipes and pipelines (conduits, welds, construction of supports, functions and characteristics of covering materials) Causes and generation of in-service defects	T. 6.0
G.4 Instrumentation	Same as level 2 (Pipes and pipelines) plus: Performances of instrumentation and transducing systems (Advanced) calibration systems (Advanced) transducing systems GW monitoring Undersea inspection with GW	T.5.0
G.5 Information before the test	Same as level 2 (Pipes and pipelines) plus: Parameter selection Instrumentation property Effect of products Effect of pipe specifications (diameter, thickness, construction methods, tolerances) and conditions (temperature, roughness, stress) GW indications Drafting of GW procedures	T 4.0
G.6 Inspection	Same as level 2 (Pipes and pipelines) plus: Check and assessment of procedures and instructions to examine their efficiency	T 4.0
G.7 Interpretation and relation	Same as level 2 (Pipes and pipelines) plus: Identification of defects in various industrial contexts Inspection report with information about control procedures	T 4.0
G.8 Assessment	Same as level 2 (Pipes and pipelines) plus: Thorough knowledge of assessment and classification methods. Identification of the suitable NDT method (UT, RT etc...) for defect dimensioning and/or defect growth monitoring (GW, UT etc...)	T 2.0
G.9 Quality	Personnel qualification (in accordance with ISO 9712) Check of instruments	T 2.0

Contents	Level 3 (Pipes and pipelines)	Duration (hours)
	Work procedure format Documentation traceability Other NDT qualifications and certification systems Revision of NDT applications and product standards	
G.10 Development	Recent developments for industrial and scientific GW applications	T 1.0
Total duration		T 40.0

Contents	Level 3 (Multisector method)	Duration (hours)
G.1 Introduction to NDT terms and history	Terms and definitions History of the method	T 2,0
G.2 Physical principles of the method and associated knowledge	Same as level 3 (Pipes and pipelines) plus: Revision of basic concepts of mathematics Property of guided waves in non-cylindrical structures Various types of GW methods GW modes in plates and rails Transduction Advanced transducer array configuration GW propagation at medium frequencies on structures Design of transducers for excitability of GW modes	T 14,0
G.3 Knowledge of product and method capability	Same as level 3 (Pipes and pipelines) plus: Production of plates and other non-cylindrical structures Causes and generation of in-service defects	T. 6.0
G.4 Instrumentation	Same as level 3 (Pipes and pipelines) plus: Transducing systems for different types of structures Monitoring systems	T.4.0
G.5 Information before the test	Same as level 3 (Pipes and pipelines) plus: Parameter selection Instrumentation property Effect of products GW indications Drafting of GW procedures	T 3.0
G.6 Inspection	Same as level 3 (Pipes and pipelines) plus: Check and assessment of procedures and instructions to examine their efficiency Approach for the inspection of different types of structures	T 3.0
G.7 Interpretation and relation	Same as level 3 (Pipes and pipelines) plus: Identification of defects in various industrial contexts and for various types of products Inspection report with information about control procedures	T 3.0
G.8 Assessment	Same as level 3 (Pipes and pipelines) plus: Thorough knowledge of assessment and classification methods. Identification of the most suitable NDT method (UT, RT etc...) for defect dimensioning and/or defect growth monitoring (GW, UT etc...)	T 2.0
G.9 Quality	Personnel qualification (in accordance with ISO 9712) Check of instruments Written instruction and procedure format Documentation traceability Other NDT qualifications and certification systems Revision of NDT applications and product standards	T 2.0
G.10 Development	Recent developments for industrial and scientific GW applications	T 1.0
Total duration		T 40.0

General notes

Level 1 can only be applied to the "Above ground steel pipework" sector. With regard to level 1 in "Above ground steel pipework" the following applications are included:

Straight pipes (specifically excluding any areas near other characteristics*) containing non-attenuating fluids which are either painted or insulated with a non-attenuating material (e.g. rock wool).

Level 2 can be applied to 3 sectors (Above ground steel pipework, buried pipes and pipes)

Level 2 (Above ground steel pipework) is a mandatory prerequisite for other level 2 sectors (e.g. Level 2 Buried pipes can be obtained only after achieving the certificate for Level 2 Above ground steel pipework).

The industrial experience for Level 2 is 9 months for each sector.

With regard to level 2 Above ground steel pipework the following applications are included:

Pipes containing non-attenuating fluids which are either painted or insulated with a non-attenuating material (e.g. rock wool).

With regard to level 2 in buried pipes the following applications are included:

Painted, insulated or buried pipelines (including road crossings and entry points into the underground section)

With regard to Level 2 in Pipes the following applications are included:

Internal inspection of pipes

Level 2 "Pipes and pipelines" is defined as the sum of all Level 2 sectors described in this document.

Level 3 is divided into "Pipes and pipelines" (like level 2 sectors defined in this document) and "Multisector method" which includes plates, rails and undersea pipelines. Other level 2 sectors that are significant for plates, rails and undersea pipelines will be defined in the future.

For Level 3 "Pipes and pipelines" 40 training hours are required for a candidate who has already been trained in all level 2 sectors defined in this scheme. A candidate to Level 3 "Multisector method" must have previously been trained in both all level 2 sectors defined in this scheme and Level 3 for the "Pipes and pipelines" sector.

*The term "characteristic" refers to any structural component related to the inspected duct.

Minimum training requirements. Table 2 (number of hours)

L1 (Above ground steel pipework)
80

Level 1 can only be applied to the ‘Above ground steel pipework’ sector. With regard to Level 1 in Above ground steel pipework, the following applications are included:

Straight pipes (specifically excluding any areas near other characteristics) containing non-attenuating fluids and that are painted or insulated with a non-attenuating material (e.g. rock wool).

L2 (Above ground steel pipework)	L2 (Buried pipes) *	L2 (Tubes)*
40	40	24

*A prerequisite is level 2 certification (Above ground steel pipework).

Level 2 can be applied to 3 sectors (Above ground steel pipework, buried pipes and pipes)

With regard to level 2 in Above ground steel pipework, the following applications are included:

Pipes containing non-attenuating fluids which are either painted or insulated with a non-attenuating material (e.g. rock wool).

With regard to level 2 in buried pipes, the following applications are included:

Painted, insulated or buried pipes (including road crossings and entry points into the buried section).

With regard to level 2 in Pipes, the following applications are included:

Internal inspection of pipes.

Level 3

L3 (Tubes and pipes)**	L3 (Multisector) ***
40	40

** A prerequisite is the training in all level 2 sectors defined in this document.

*** A prerequisite is the training in all level 2 sectors defined in this and training in Level 3 for the Pipes and pipelines sector.

Minimum experience requirements¹ Table 3 (months)

L1	L2 ^	L3 ^^
3	9	36

¹ Experience is preferably verified automatically.

^ Industrial experience for level 2 is 9 months for each sector.

^^ “Industrial experience” refers to the experience as Level 2 Inspector in the Above ground steel pipework sector.

Industrial experience prior to examination 6.3.1

L1	L2	L3
100%	100%	100%

Qualification examinations 7.

Table 4

General examinations:

Minimum required number of questions: 40

7.2.2 Specific examination

Level 1 Minimum required number of questions: 20
Level 2 Minimum required number of questions: 30

In addition to a practical examination with a sample (in accordance with the requirements set out in the ISO 9712 standard), the candidate shall be subject to an examination with computer simulation.

For level 3 qualification examinations, in addition to the examinations listed in the ISO 9712 standard, the candidate shall draft two procedures (in two of the sectors defined in this document).