

GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)**Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)**

Semester -V

Course Title: Welding Inspection & Testing

(Course Code: 4355505)

Diploma programmer in which this course is offered	Semester in which offered
Fabrication Technology	5 th Semester

1. RATIONALE

Welding is becoming essential joining process in fabrication and manufacturing industry. In process equipment fabrication industry, structural fabrication industry, piping industry, ship construction industry etc. welding is essential process for metal joining. Quality of weld joint is depends on proper preparation of WPQ, WPS and PQR. So, it is compulsory for a fabrication engineer to prepare and interpret the WPQ, WPS and PQR. Welding is very complex metal joining process due to its very fast heating and cooling cycle. There may be many discontinuities found in welding. Welding inspector must have knowledge and skill to identify these discontinuities. He / She have the ability to identify the defects, its sources and probable remedies. Mechanical properties like tensile strength, yield strength, ductility, hardness, impact strength, chemical properties etc., are essential to be evaluated for judging the quality of weld joint. Many destructive testing processes are used for finding strength, homogenization and mechanical properties of weld joint. Many codes and standards are applicable in fabrication industry for these destructive testing procedure and sample preparation. Destructive testing is performed on production test coupon. But on actual production weld joint nondestructive tests are performed to discover the defects. It is necessary for fabrication engineer to have the knowledge of these nondestructive processes and its applicable codes and standards. This course is designed to develop these essential qualities of welding inspector in students.

2. COMPETENCY

The course content is leading to the achievement of the following competency:

- **Develop essential qualities of welding inspector for fabrication industries by identification of quality of weld with use of destructive and nondestructive testing of it and WPS, PQR & WPQ.**

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with the identified competency are to be developed in the student for the achievement of the following COs:

- Describe importance of welding inspection, testing & weld metal discontinuities.
- Prepare basic PQR/WPS/WPQ as per applicable code used in fabrication industry.
- Describe various destructive testing used for weld joint testing.
- Use appropriate visual inspection, liquid penetrate testing and magnetic particle testing for a given application.
- Describe various non-destructive test like (ultrasonic test, radiography test, eddy current test, leak test, phased array) used for weld joint.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				Total Marks
L	T	P		Theory Marks		Practical Marks		
			C	CA	ESE	CA	ESE	
4	0	2	5	30*	70	25	25	150

(*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessing the attainment of the cognitive domain UOs required for the attainment of the COs.

Legends: L-Lecture; T – Tutorial/Teacher Guided Theory Practice; P -Practical; C – Credit, CA - Continuous Assessment; ESE -End Semester Examination.

5. SUGGESTED PRACTICAL EXERCISES

The following practical outcomes (PrOs) are the sub-components of the COs. *These PrOs need to be attained to achieve COs.*

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Draw basic welding symbols & their location significance with examples.	I	02
2	Draw basic testing symbols & their standard location with examples.	I	02
3	Draw Desirable, acceptable and unacceptable fillet weld & butt weld profiles.	I	02
4	Demonstrate various welding discontinuities.	I	02
5	Prepare typical sample procedure qualification record (PQR) from the given data.	II	02
6	Prepare typical sample welding procedure specification (WPS) from the given data.	II	02
7	Prepare sample welder performance qualification (WPQ) from the given data.	II	02
8	Perform Rockwell hardness test on given a job.	III	02
9	Demonstrate tensile test on a given job.	III	02
10	Demonstrate impact test on a given job.	III	02
11	Demonstrate liquid penetrant test on a given job.	IV	02
12	Demonstrate magnetic particle test on a given job.	IV	02
13	Demonstrate ultrasonic test on a given job/calibration block.	V	02
14	Identify weld discontinuity by inspecting radiography film.	V	02
TOTAL HRS.			28

Note

- i. More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.
- ii. Boiler suit, safety shoes and necessary hand tools & instruments are compulsory while attending laboratory and has to be bought by students. (Annexure-1)

The following are some sample 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed Practical Exercises of this course required which are embedded in the COs and ultimately the competency.

Sr. No.	Sample Performance Indicators for the PrOs	Weightage in %
For PrOs no: 8		
1	Knowledge of experiment	20
2	Performance	30
3	Procedure followed	30
4	Quality of report	10
5	Punctuality	10
Total		100

Sr. No.	Sample Performance Indicators for the PrOs	Weightage in %
For PrOs no: 4 to 7 & 9 to 14		
1	Knowledge of experiment	30
2	Quality of report	30
3	Participation	20
4	Punctuality	10
5	Originality	10
Total		100

Sr. No.	Sample Performance Indicators for the PrOs	Weightage in %
For PrOs no: 1,2,3		
1	Knowledge.	20
2	Drawing Layout, Planning & Scale	20
3	Neatness & completeness	30
4	Dimensions (accuracy)	20
5	Punctuality	10
Total		100

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

These major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to use in uniformity of practicals in all institutions across the state.

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
1.	Drawing instruments.	1,2,3
2.	Test pieces/samples of jobs welded with different welding processes.	4
3.	Rockwell hardness testing machines, calibration block, suitable indenter, test pieces/samples.	8
4.	Universal testing machines, tensile test specimen	9
5.	Charpy/Izod impact test machines, impact test specimen	10
6.	Cleaner, penetrant, developer of solvent removable method, cotton waste.	11
7.	AC electromagnetic yoke machine, dry/wet application magnetic	12

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
	particles, pie field indicator.	
8.	Digital ultrasonic flaw detector, IIW V1/V2 calibration block, reference block.	13
9.	Radiography film viewer, sample radiographs of welded jobs.	14

7. AFFECTIVE DOMAIN OUTCOMES

The following **sample** Affective Domain Outcomes (ADOs) are embedded in many of the above-mentioned COs and PrOs. More could be added to fulfill the development of this course competency.

- a) Follow safety practices in laboratory.
- b) Practice good housekeeping.
- c) Work as a leader/a team member.
- d) Maintain tools/equipment
- e) Follow ethical practices

The ADOs are best developed through the laboratory/field-based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- i. 'Valuing Level' in 1st year
- ii. 'Organization Level' in 2nd year.
- iii. 'Characterization Level' in 3rd year & 4th year.

8. UNDERPINNING THEORY

The major underpinning theory is given below based on the higher level UOs of *Revised Bloom's taxonomy* that are formulated for development of the COs and competency. If required, more such UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
Unit-I Basics of welding inspection, testing & discontinuities.	1a. Describe need & importance of welding inspection & testing. 1b. Illustrate welding and testing symbols. 1c. Classify weldment related discontinuities. 1d. Suggest remedies of weldment related discontinuities.	1.1 Scope, Definition, Application 1.2 Comparison of Welding Symbol with written explanation. 1.3 Basic elements of Testing Symbols as per AWS A2.4 1.4 Examples of typical NDT symbols. 1.5 Basic Testing Symbols 1.6 Illustration of Welding & Testing Symbols. 1.7 Ethical and essential requirements for the Welding Inspector. 1.8 Quality Assurance for WI&T. 1.9 Classification of welding related discontinuities 1.10 Desirable, acceptable and unacceptable fillet weld profiles.

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
		1.11 Acceptable and unacceptable Butt weld profiles. 1.12 Weldment & related discontinuities. (Porosity, slag Inclusion, tungsten inclusions, incomplete fusion, inadequate Joint Penetration, undercut, cracks)
Unit: II WPS, WPQ, PQR	2a. Define WPS/WPQ/PQR 2b. Describe importance of WPS/WPQ/PQR 2c. Prepare typical WPS/WPQ/PQR as per given condition.	2.1 Description, Application important details, Example of Qualification WPS. 2.2 Preparation of sample joints 2.3 Testing of representative samples 2.4 Evaluation of overall preparation, welding testing & end results 2.5 Changes in Qualified procedure 2.6 Approval of Test and WPS 2.7 Welding performance qualification 2.8 Performance qualification requirements 2.9 Test specimen 2.10 Testing of qualification welds 2.11 Qualification records 2.12 Standardization of tests 2.13 Relation of qualification tests to welder training 2.14 Retests 2.15 Sample welder qualification test record
Unit: III Destructive tests	3a. Define destructive tests. 3b. Describe tensile test. 3c. Describe bend test. 3d. Describe hardness test. 3e. Describe nick break test and etch test.	3.1 Tensile test: Introduction, preparation of test specimen, test procedure, results 3.2 Bend test: Introduction, purpose, types of tests, specimens & procedure. 3.3 Impact test: Introduction, types, procedure, results 3.4 Nick break test: Purpose, test specimen, procedure 3.5 Hardness test: Purpose, types, machines, procedure 3.6 Etch test: Introduction, types, concept & purpose, preparation of test specimen
Unit- IV NDT Methods (VT, LPT, MPT)	4a. Compare destructive tests & nondestructive tests. 4b. Describe visual test. 4c. Perform liquid penetrant test. 4d. Perform magnetic particle test on a given sample.	4.1 Comparison of destructive & nondestructive test 4.2 Visual inspection: basic principle, defects detected, optical aids, application 4.3 Liquid penetrant testing: principle, procedure, testing materials, testing methods, sensitivity, application, advantages, limitation, codes & standards.

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
		4.4 Magnetic particle testing: definition & principle, magnetizing techniques, procedure, equipment, sensitivity, advantages, limitation, codes & standards.
Unit– V NDT Methods (UT, ET, RT, LT, Phased array)	5a. Describe ultrasonic test. 5b. Describe eddy current test. 5c. Describe radiographic test. 5d. Describe leak tests. 5e. Describe phased array test. 5f. Compare NDT methods. 5g. Select NDT methods. 5h. Describe importance of NDT codes & standards.	5.1 Ultrasonic testing: Introduction, principle, properties of sound beam, transducers, classification of UT techniques, techniques for normal beam inspection, techniques for angle beam inspection, equipments, modes of display, advantages, limitations, application, codes & standards. 5.2 Eddy current testing: principle, metal properties & its effect, instrumentation, techniques, sensitivity, advantages, limitations, applications. 5.3 Radiographic testing: principle, radiation sources, effect of radiation on film, procedure, inspection techniques, advantages, limitations, application, typical examples. 5.4 Leak testing: measurement of leakage, bubble leak testing, helium leak detection. 5.5 Phased array testing (Introduction, principle, advantages & disadvantages) 5.6 Comparison of NDT methods 5.7 Selection of NDT of methods 5.8 Codes & standards for NDT: Meaning of codes, standard, specification, procedures, national & international standards for NDT

9. SUGGESTED SPECIFICATION TABLE FOR QUESTIONPAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Basics of welding inspection, testing & discontinuities.	08	4	7	0	11
II	WPS/WPQ/PQR	12	3	4	7	14
III	Destructive tests	10	3	4	4	11
IV	NDT Methods (VT, LPT, MPT)	12	3	7	4	14

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
V	NDT Methods (UT, ET, RT, LT, Phased array)	14	3	10	7	20
	TOTAL	56	16	32	22	70

Legends: R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks and marks at different taxonomy levels (of R, U and A) in the question paper may vary slightly from above table.

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related **co-curricular** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should perform following activities in group and prepare reports/charts for each activity. They should also collect/record physical evidences for their (student's) portfolio which may be useful for their placement interviews:

- Prepare solutions of different assignments given by subject faculty.
- Prepare a list of specifications for various tools/equipment/machines used for welding inspection & testing
- Visit the local metal trader/ fabricator and collect all relevant information regarding LPT & MPT tools/equipments.
- Download videos showing correct practices for destructive testing and non-destructive testing.
- Collect videos, animation showing welding discontinuities, PQR/WPS/WPQ, destructive tests & non-destructive tests.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

- Massive open online courses (**MOOCs**) may be used to teach various topics/sub topics.
- Guide student(s) in undertaking micro-projects.
- 'L' in section No. 4** means different types of teaching methods that are to be employed by teachers to develop the outcomes.
- About **20% of the topics/sub-topics** which are relatively simpler or descriptive in nature is to be given to the students for **self-learning**, but to be assessed using different assessment methods.
- With respect to **section No.10**, teachers need to ensure to create opportunities and provisions for **co-curricular activities**.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-projects are group-based (group of 3 to 5). However, **in the fifth and eighth semesters**, the number of students in the group should **not exceed three**.

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The duration of the micro project should be about **14-16 (fourteen to sixteen) student engagement hours** during the course. The students ought to submit micro-project by the end of the semester to develop the industry-oriented COs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

- a) Prepare report on the topic given by the subject teacher within the syllabus or beyond the syllabus from different books, technical magazines, journals etc.
- b) Prepare video on demonstrating different destructive tests/non-destructive tests.
- c) Prepare sample WPS/PQR from the given situation/data/drawing.
- d) Prepare a power point presentation of 10 to 15 slides on the topic given by the subject teacher within the syllabus or beyond the syllabus.
- e) Prepare report and/or download video on the topic given by the subject teacher within the syllabus or beyond the syllabus from internet or any other online resources.
- f) Perform one of the NDT methods on existing machines/parts & prepare report on it.
- g) Prepare charts/posters of welding inspection & testing related topics.

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
1	Welding Inspection	AWS Committee	American Welding Society
2	Practical Non Destructive Testing	Baldev Raj T.Jaykumar M.Thavasimuthu	Narosa Publishing House
3	NDT Hand Book Vol.1&3	ASNT Committee	American Society of Non Destructive Test.
4	Non Destructive Testing Techniques	Ravi Prakash	New Age Science Publication
5	ASME Sec-II,V,VIII,X	ASME Committee	American Society of Mechanical Engineers
6	Welding Technology	O.P.Khanna	Dhanpatrai publication
7	Welding Engineering & Technology	Dr. R.S.Parmar	Khanna Publishers
8	Mechanical Design and Fabrication of Process Equipment	B C Bhattacharya	Oscar Publication
9	Welding Technology for Engineers	Baldev raj	Narosa Publishing House
10	Welding Technology & design	V.M. Radhakrishnan	NEW AGE INTERNATIONAL PUBLISHERS
11	Video Series on Welding and its Testing	-----	BHEL Trichi and NITTTR Bhopal

14. SOFTWARE/LEARNING WEBSITES

- <https://isnt.in/>
- <https://asnt.org/>
- <https://www.youtube.com/watch?v=5cNWF61Tmj0&list=PLyAZSyX8Qy5AePdV6vbGP4OJQOpbga-0Q>
- <https://www.youtube.com/watch?v=sfjK1GZ2W9A&t=134s>
- <https://www.youtube.com/watch?v=ZMJ7O4vs-Q8>
- <https://www.youtube.com/watch?v=IAH8hm580Zg>
- https://www.youtube.com/watch?v=7oR_l8nXdmo
- <https://www.youtube.com/watch?v=qpgcD5k1494>
- <https://www.youtube.com/watch?v=8l1onrUqjDA&t=8s>
- <https://www.youtube.com/watch?v=oriFJByl6Hs&t=23s>

15. PO-COMPETENCY-CO MAPPING

Semester: V	Welding Inspection & Testing (Course Code:4355505)						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/development of solutions	PO 4 Engineering Tools, Experimentation & Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning
Competency	• Develop essential qualities of welding inspector or fabrication industries by identification of quality of weld with use of destructive and nondestructive testing of it and WPS, PQR & WPQ.						
Course Outcomes							
co 1) Describe importance of welding inspection, testing & weld metal discontinuities.	3	1	1	2	-	-	1
co 2) Prepare basic PQR/WPS/WPQ as per applicable code used in fabrication industry.	3	2	1	-	1	-	2
co 3) Describe various destructive testing used for weld joint testing.	2	1	1	3	1	-	2
co 4) Use appropriate visual inspection, liquid penetrate testing and magnetic particle testing for given application.	2	1	1	3	1	-	2
co 5) Describe various	2	1	1	3	1	-	1

nondestructive test like (ultrasonic test, radiography test, eddy current test, leak test, phased array) used for weld joint.							
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Legend: '3' for high, '2' for medium, '1' for low and '-' for no correlation of each CO with PO.

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

Sr. No.	Name and Designation	Institute	Contact No.	Email
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