

SAULT COLLEGE OF APPLIED ARTS AND TECHNOLOGY
SAULT STE. MARIE, ON

COURSE OUTLINE

COURSE TITLE: WELDING METALLURGY

CODE NO.: WDF112 SEMESTER: WINTER

PROGRAM: WELDER / FITTER

AUTHOR: D. SOCCHIA

DATE: 1994 07 22 PREVIOUS OUTLINE DATED: 1993-06-04

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Welding Metallurgy
COURSE NAME

WDF112
COM NO.

TOTAL CREDITS 3

PREREQUISITE(S): Welding Practices and Procedures (WDF100), Fabrication & Layout -1 (WDF102), plus the ability to read, write and comprehend at the Grade 10 general... OR... the combined equivalent

PHILOSOPHY/GOALS:

To provide students with a reasonable understanding of the basic concepts related to the weldability of carbon steels. Secondly, to make students aware of the increasing demand placed upon them by the many welding codes and/or material specifications in use by the fabrication industry.

n. STUDENT PERFORMANCE OBJECTIVES (OUTCOMES):

Upon successful completion of this course the student will:

- 1) Understand mechanical properties well enough to appreciate the need for careful electrode selection.
- 2) Appreciate the characteristics and quality of rolled plate.
- 3) Recognize the numerous variables that have the potential to affect the quality and soundness of a weld.
- 4) Respect the demands of CSA and/or ASME welding codes and material specifications.

m. TOPICS TO BE COVERED;

**Approximate Time
Frames (Optional)**

	Course Introduction and Orientation	2 hrs
%	Common Base Metals and Mechanical Properties	10 hrs
	Theory Test # 1 and Review	2 hrs
3)	Electrode Selection	8 hrs
	Theory Test # 2 and Review	2 hrs
4)	Basic Heat Treatments and Heat Affected Zone	12 hrs
	Theory Test # 3 and Review	2 hrs
5)	Cold Cracks vs Hardness and Hydrogen Control	12 hrs
	Theory Test #4 and Review	2 hrs

IV. LEARNING ACTIVITIES/REQUIRED RESOURCES**Topic/Unit - # 1. Course Introduction and Orientation****Learning Activities:**

1.1 > A lecture presentation of the following major course documents:

- a) course outline
- b) course guidelines
- c) course marking system including attendance requirements

Rewards;

- > printed handouts, overheads, chalkboard notes

Topic/Unit - #2 Common Base Metals and Mechanical Properties**Learning Activities:**

2.1 > A classroom demonstration and lecture discussion of the following mechanical properties:

- a) elasticity and elastic limit
- b) yield strength
- c) tensile strength
- d) ductility
- e) toughness
- f) hardness and brittleness

2.2 > Create definitions for the above mechanical properties based upon the major concepts observed and discussed during the classroom demonstration.

2.3 > List and briefly describe the units of measurement for each of the above mechanical properties.

2.4 > List and briefly describe the importance of mechanical properties as they relate to the welding trade.

2.5 > Prepare samples for shop and lab testing from the following list of base metals.**

- a) aluminum
- b) mild steel
- c) stainless steel
- d) 100 QT
- e) 425 AR

**** NOTE: Samples are prepared by instructor from pre-ordered stock.**

- 2.6 > A series of shop experiments to help identify the general mechanical properties in the above group of pre-selected steels.
 - a) file scratch
 - b) chip
 - c) guided bend
 - d) brinell hardness
 - 2.7 > Lab experiments that help to identify specific mechanical properties in the above group of pre-selected metals.
 - a) rockwell hardness
 - b) tensile
 - 2.8 > Classroom discussion and summary of previous lab / shop experiments and resulting data.
 - 2.9 > A lecture presentation with classroom discussion of the relationship between the mechanical properties of a metal and its general weldability.
 - 2.10 > Independent module reading assignment c/w review questions based upon the following major items:
 - a) the grades of ingot poured / continuous cast steel
 - b) the directional properties of hot rolled steel
 - c) common weld problems associated with directional properties as well as the various grades of steel

(Met Module, p 8,9» 10,11,12)
- > Met Module, pre-selected metal samples, welding shop facility, metallurgy lab, printed handouts, chalkboard notes and assignment sheets.

Topic/Unit!- THEORY TEST#1 and REVIEW

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- > Test Booklets, Student Response Sheets and Grade/Answer Sheets

Topic/Unit; - #3 Electrode Selection

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- 3.1 > A lecture presentation with classroom discussion of the following major items:
 - a) requirements of a 'sound weld'
 - b) identification / location of typical weld cracks
- 3.2 > A video presentation with classroom discussion of the metallurgical concepts behind electrode selection.

(WIC Module # 6, p 17,18,19,20,21,22, 23,24,25)

- 3.3 > A classroom discussion and analysis of the frequently used base metal and electrode combinations for the purpose of clarifying:
- a) why they are used
 - b) why they are successful
 - c) possible misconceptions
- 3.4 > A lecture presentation with classroom discussion of specific electrode / base metal combinations according to:
- a) CSA Standard W59.1
 - b) AWS Standard D1.1
 - c) Constructional Steel Handbook
 - d) Electrode Manufacturer's Handbook
- 3.5 > Independent module reading assignment c/w review questions based upon the above material
- Rgs<>^r<^;
- > Met Module, WIC Module # 6, Constructional Steel Handbook, electrode pocket guide, chalkboard notes, printed handouts and assignment sheets.

Topic/Unit: - THEORY TEST # 2 and REVIEW

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- > Test Booklets, Student Response Sheets and Grade/Answer Sheet

Topic/Unit!- #4 Basic Heat Treatments and Heat Affected Zone

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- 4.1 > A lecture presentation with classroom discussion of the various crystalline structures that exist in hot rolled and normalized, plain carbon steel at room temperature.
(Met Module, p 19,20,21)
- 4.2 > A series of shop demonstrations that illustrate the following basic heat treatments:
- a) anneal / normalize
 - b) water quench-harden
 - c) oil quench-harden
 - d) temper / stress relieve
- 4.3 > A lecture presentation with classroom discussion of the various crystalline structures that can be created as a result of the above heat treatments.
(Met Module, p 22,23, and printed handouts)

- 4.4 > A series of shop demonstrations that illustrate the effects of heat treatment upon the following mechanical properties:
 - a) strength
 - b) ductility
 - c) hardness
- 4.5 > Independent research assignment on the topic of 'Basic Heat Treatments' that defines:
 - a) the temperatures and procedures involved in each process
 - b) the net effect upon crystalline structure and mechanical properties (Weld Dept Reference Library)
- 4.6 > A lecture presentation with classroom discussion of the individual zones in the EL[^]Z of a completed weldment that includes the following major items:
 - a) the origins, heat input and mechanics of the ELiZ
 - b) final £ i Z structures resulting from a normalized weld
 - c) final HAZ structures resulting from a quenched weld
- 4.7 > A lecture presentation with classroom discussion of the major factors affecting the extent of change in crystalline structure for a given HAZ.
- 4.8 > Slide presentation of various test welds, their resulting data plus a summary of topic areas.

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- > Met Module, Weld Dept Reference Library, printed handouts, chalkboard notes plus assignment sheets.

Topic/Unit: THEORY TEST #3 and REVIEW

- > Test Booklets, Student Response Sheets and Grade/Answer Sheet

Topic / Unit: - #5 Cold Cracking vs Hardness and Hydrogen Control

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- 5.1 > A lectnre presentation with classroom discussion of the following items:
 - a) ^ I c a l weld and base metal cracks
 - b) detrimental properties of hydrogen
 - c) potential sources of hydrogen contamination (Met Module, p 58,71,72,73)
- 5.2 > A lecture presentation with classroom discussion of the following
 - a) the mechanism of hydrogen absorption and retention
 - b) elimination of hydrogen from the completed weldment (Met Module, p 69,70,71,72.74)

- 5.3 > Independent module reading assignment c/w review questions.
(WIC Module # 6, p 25, 26, 2-28)
- 5.4 > Experimental shop welds on a variety of steels using a pre-determined sequence to include:
 - a) joint design
 - b) degree of restraint
 - c) electrode size / type
 - d) amperage
 - e) stringer vs weave technique
 - f) preheat vs postheat
- 5.5 > A lecture presentation with classroom discussion of the following items:
 - a) conditions necessary for hydrogen cracking to occur
 - b) the concept, formula and application of carbon equivalent
(Met Module, p 75, 76, 77)
- 5.6 > A series of experimental shop tests on previously completed weldments to detect the presence of surface cracks and possible changes in mechanical properties:
 - a) visual examination
 - b) dye penetrant
 - c) hardness
- 5.7 > A lecture presentation with classroom discussion of the following major items:
 - a) the use of preheat, weld size and postheat to control hardness and hydrogen content
 - b) the concept, formula and relevance of energy / heat input.
(Met Module, p 61,62) (WIC Module # 6, p 80, 81, 82, 83, 84, 85)
- 5.8 > Independent module reading assignment c/w review questions.
- 5.9 > A lecture presentation with classroom summary of this topic by means of hardening curves and crack prevention techniques for the following steels:
 - a) conventional carbon
 - b) alloy
 - c) micro-alloy, fine grain
- 5.10 > Independent research assignment using hypothetical situations that involve cold cracking of fabricated weldments.
(Met Module, WIC Modules)

Resources:

- > Met Module, WIC Module # 6, welding shop, printed handouts, chalkboard notes and assignment sheets.

Topic/Unit: THEORY TEST # 4 and REVIEW

Resources:

- > Test Booklets, Student Response Sheets and Grade/Answer Sheet

COURSE NAME _____ CODE NO.

EVALUATION METHODS: (INCLUDES ASSIGNMENTS, ATTENDANCE REQUIREMENTS, ETC.)

Grade	Final Mark*	
A = 85 - 100 %	Theory Tests	75 %
B = 75 - 84 %	Independent Assignments	25 %
C = 60 - 74 %		
D = 50 - 59 %	Attendance (**See Attached)	
F = 0 - 49 %		

VI. PRIOR LEARNING ASSESSMENT:

Students who wish to apply for advanced credit in the course should consult the instructor. Credit for prior learning will be given upon successful completion of the following:

1. The successful completion of a welding metallurgy course with student outcomes and course topics that are at least 80 % compatible with WDF1 12.
2. The successful completion of all four WDF1 12 theory tests and a resulting average mark of at least 75 %.
3. Written proof of at least five (5) years of trade or industrial experience dealing with the competent application of welder metallurgy.

VII. REQUIRED STUDENT RESOURCES

Safety Glasses (Impact Resistant)

Safety Work Boots

Met Module "Steel Welding Metallurgy"

WIC Module # 6 "Electrodes and Consumables for Welding"

The Metal Trades Handbook

IX. SPECIAL NOTES

Students with special needs (eg. physical limitations, visual impairments, hearing impairments, learning disabilities) are encouraged to discuss required accommodations confidentially with the instructor.

Your instructor reserves the right to modify the course as he/she deems necessary to meet the needs of students.

* Student Evaluations concerning the Final Mark* are further affected by the conditions set forth in the printed handout, * **Guidelines for Welder / Fitter Program** *

** Special Guidelines for class attendance are included in the above paper.

**GUIDELINES
FOR
WELDING METALLURGY**

The following guidelines apply to all full time students who undertake this course of study at Saolt College.

1. ATTENDANCE

1.1 Students are required to:

- a) Be present for each class**
- b) Be in the shop or classroom within 5 minutes of the scheduled starting time**
- c) Be present for the taking of attendance at the beginning and at the end of each class.**

1.2 If you are absent from class at the time of attendance, you will be marked absent for that hour.

1.3 Students are required to leave a telephone message with their instructor(s) whenever they must be absent from class. The message should clearly indicate both the reason for the absence as well as the anticipated duration.

TEL: 705-759-2554 Ext 602

1.4 If you are marked 'absent*' and no reasonable excuse is given (ie. illness, accident, personal emergency, employment reasons) your absence will be termed 'UNEXCUSED'.

1.5 Students will lose 1% from their final course grade for each hour of UNEXCUSED absence.

1.6 Make up lessons are not possible .

1.7 If you are absent from class, the lesson material is your responsibility. Printed handouts and / or reading assignments may be obtained from your instructor if so requested. Chalkboard notes must be obtained from your fellow students.

1.8 Students who accumulate 10 or more hours of unexcused absence shall be deemed to have quit the course.

1.9 Students wishing to return to class after 10 or more hours of unexcused absence be required to make a written request to the Dean's Office explaining the circumstance of his / her absence.

1.10 If the request is denied, the student shall not return to class.

BEHAVIOUR / ATTITUDE

- 2.1 Students are required to:
 - a) Properly care for and maintain all shop and classroom equipment.
 - b) Properly clean the shop/classroom facility and equipment at the end of each
 - c) Remain in the shop/classroom at the completion of each class to assist in the cleaning and shutting down of their shop/classroom.
- 2.2 Students are expected to conduct themselves in a manner that does not interfere with or obstruct the overall learning environment.
- 2.3 The following activities are not allowed in the shop/classroom.
 - a) horseplay
 - b) swearing
 - c) abusive behaviour
 - d) smoking, eating, drinking, sleeping
 - e) doing homework or assignments from another class.

ASSIGNMENTS **and** THEORY TESTS

- 3.1 Students are required to hand in assignments or write theory tests on the day and at the time specified.
- 3.2 Students who do not hand in assignments or write theory tests on the day and at the time specified must request a rescheduling of the event **in writing** within 7 calendar days of the specified due date, ... or, ... the student's return to class.
- 3.3 Assignments and theory tests will be rescheduled at the instructor's discretion.
- 3.4 Where no reasonable excuse is given (ie. car accident, death in the family, serious illness, employment reasons etc...) rescheduled assignments and theory tests will be graded as follows:
 - a) One day after the original due date - 70% Maximum
 - b) Two or more days after the original due date - 50% Maximum.
- 3.5 Any person caught cheating or substituting another person's work in place of their own for the purpose of grading or evaluation will automatically forfeit the said assignment or theory test. College policy also dictates that such persons may be subject to immediate dismissal.

RE-WRITES

There are no re-writes. All evaluations are permanent and will affect your final course grade.

RETURN OF GRADED PAPERS

It shall be the normal expectation that all assignments and theory tests will be returned to students after grading. Whenever this practice cannot be followed, notice will be provided.

COURSE CREDITS

Credit may be granted for this course based upon the submission of written proof that the student has successfully completed a welding metallurgy course having student outcomes and course topics that are at least 80% compatible with the present course of instruction. Credit must have School approval prior to the published add/drop deadline dates for each semester.

It is the responsibility of the student to apply for credit with the appropriate documentation which shall include all of the following:

- a) the student's full name
- b) the course number (or numbers)
- c) a verified course description outlining student outcomes and course topics
- d) the final grade received
- e) the date of successful completion.

7 SAFETY

7.1 Contact lenses **most not** be worn in the shop or lab areas at any time.

7.2 Students are required to wear their personal protective equipment (ie. CSA approved safety work boots and impact resistant safety glasses) at all times while in the shop or lab area.

7.3 Students are required to replace any or all pieces of personal protective equipment (such as clothing, gloves, work boots, and safety glasses) that become unsafe, begin to show signs of damage or excessive wear.

7.4 Students must use and/or wear additional protective equipment whenever exposed to the hazards of welding, shaping and forming metals.

7.5 Students must not enter shop OT lab areas or commence work before their scheduled time.

7.6 Students must not work alone or in an unattended area.

7.7 Students can expect to be given a minimum of one 20 minute 'coffee break' at the midpoint of their shop/lab activity.

7.8 Students must not use or operate equipment that is found to be unsafe or damaged. All such equipment must be identified to the welding instructor or the shop/lab technician who will replace or repair the said equipment

- 7.9 Where damaged or unsafe equipment cannot be repaired or replaced, the instructor will provide alternate student activity.
- 7.10 Students must follow instructions and proper safe work practices in order to use or operate any shop/lab equipment.
- 7.11 Classes will be monitored on a daily basis to ensure that:
- a) all personal safety equipment is worn by all persons at all times
 - b) described safe work practices are followed by all persons at all times.

8 DISCIPLINE

Failure to comply with any of the guidelines relating to 'Behaviour / Attitude' or 'Safety*' may result in the student being ejected from classroom or shop/lab area and marked with an UNEXCUSED absence. Repeated violations shall result in the student(s) being placed on a Behavioral Contract.