The Japan Society of Mechanical Engineers Code for Fusion Facilities

Rules on Superconducting Magnet Structure APPENDICES

CONTENTS

APPENDIX 11 QUALIFIED INSPECTION OF SUPERCONDUCTI	NG
MAGNETS	
11-1000 GENERAL PRINCIPLES · · · · · · · · · · · · · · · · · · ·	1-1
11-1100 APPLICABILITY · · · · · · · · · · · · · · · · · · ·	
11-1200 IMPLEMENTATION OF INSPECTION	
11-1210 QUALIFIED INSPECTION FUNCTION 1	
11-1220 QUALIFIED INSPECTOR····	
11-1300 DUTIES OF QUALIFIED INSPECTOR ······ 1	1-2
11-1310 GENERAL INSPECTION DUTIES 1	1-2
11-1320 CATEGORIES OF QUALIFIED INSPECTOR'S DUTIES 1	1-2
11-1330 QUALITY ASSURANCE PROGRAM ·····	1-3
11-1331 Stipulation of Inspections · · · · · · 1	1-3
11-1332 Quality Assurance Program Monitoring · · · · · · 1	
11-1333 Process Control Check List · · · · · · · 1	1-3
11-1340 REVIEW OF QUALIFICATION RECORDS ·····	
11-1341 Welding Procedures 1	1-3
11-1342 Welders and Welding Operators ·····	1-4
11-1343 Nondestructive Examination Procedures · · · · · 1	1-4
11-1344 Nondestructive Examination Personnel · · · · · · 1	1-4
11-1350 MATERIALS, PARTS, AND HEAT TREATMENT ······	1-5
11-1351 Inspection of Material Compliance · · · · · · · · · · · · · · · · · · ·	1-5
11-1352 Check of Dimension · · · · · 1	1-5
11-1353 Check of Heat Treatment Practice · · · · · 1	1-5
11-1360 EXAMINATION AND TESTS · · · · · · · · · · · · · · · · · ·	1-5
11-1370 FINAL TESTS	1-6
11-1380 DATA REPORTS	1-6

APPENDIX 12 DUTIES OF STANDARD-EXPERT ENGINEERS FOR SUPERCONDUCTING MAGNETS
12-1000 GENERAL PRINCIPLES 12-1
12-1100 APPLICABILITY
12-1200 STANDARD-EXPERT ENGINEER · · · · 12-1
12-1300 DUTIES OF STANDARD-EXPERT ENGINEERS 12-2
12-1310 GENERAL DUTIES REGARDING REVIEW OF DESIGN
DOCUMENTS 12-2
12-1320 DESIGN DOCUMENTS TO BE REVIEWED 12-2
12-1330 REVIEW OF DESIGN DOCUMENTS 12-2
12-1331 General
12-1332 Design Specifications · · · · · 12-2
12-1333 Design Drawing, Design Analysis Report, and Design Report · · · · · · 12-3
12-1334 Fabrication Specifications 12-4
12-1335 Installation Specifications ··········12-4
APPENDIX 21 STANDARD FOR STRUCTURAL MATERIAL 21-1000 HIGH MANGANESE STAINLESS STEEL FOR MAGNET
STRUCTURE
21-1100 MANUFACTURING METHOD 21-1
21-1200 HEAT TREATMENT
21-1300 CHEMICAL COMPOSITION21-1
21-1400 MECHANICAL PROPERTIES · · · · 21-1
21-1500 TEST METHOD
21-1600 RETEST
21-2000 STAINLESS STEEL FOR STRUCTURE ······21-3
21-2100 MANUFACTURING METHOD 21-3
21-2200 HEAT TREATMENT
21-2300 CHEMICAL COMPOSITION21-3
21-2400 MECHANICAL PROPERTIES21-4
21-2500 TEST METHOD
21-2600 RETEST

21-3000 STAINLESS STEEL PIPING FOR JACKET ·····	21-5
21-3100 MANUFACTURING METHOD	21-5
21-3200 HEAT TREATMENT ······	21-5
21-3300 CHEMICAL COMPOSITION ·····	21-5
21-3400 MECHANICAL PROPERTIES ·····	21-5
21-3500 TEST METHOD	21-5
21-3510 TENSILE TEST ·····	21-5
21-3520 FLATNESS TEST ·····	21-5
21-3600 RETEST	21-6
APPENDIX 22 SPECIFICATIONS FOR WELDING MATERIAL	
22-1000 WELDING WIRE FOR TIG WELDING	22-1
22-1100 CHMICAL COMPOSITION ·····	22-1
APPENDIX 23 GUIDELINES FOR APPLYING NEW MATERIAL	
23-1000 GENERAL	
23-2000 APPLICATION PROCEDURE ·····	23-1
23-3000 SUBMITTED DOCUMENTS ·····	23-2
23-3100 BASIC COMPONENTS AND USE OF MATERIAL ······	23-2
23-3110 MATERIAL SPECIFICATIONS	23-2
23-3120 MANUFACTURING METHODS AND CONDITIONS	23-2
23-3130 SERVICE CONDITIONS AND EXPERIENCES	23-2
23-3140 PROPERTIES AND PARTICULAR LIMITATIONS in	USING the
NEW MATERIAL	23-2
23-3141 Characteristics · · · · · · · · · · · · · · · · · · ·	23-2
23-3142 Patent and License ·····	23-3
23-3200 TEST DATA FOR BASE MATERIAL	23-3
23-3210 TEST SPECIMENS AND TEST METHOD	23-3
23-3220 TEST DATA TO BE SUBMITTED	23-3
23-3221 Chemical Composition (Heat and Product Analyses)	23-3
23-3222 Macrostructure and Microstructure ······	23-3
23-3223 Mechanical Properties · · · · · · · · · · · · · · · · · · ·	23-3

23-4
23-4
23-4
GTH23-5
23-5
31-1
31-1
31-1
Stainless
31-1
nless Steel
······31-2
31-2
41-1
41-1
41-1
41-1
41-1
41-1
41-2
41-2
41-2
41-2
41-2
41-2
JOINT
······41-2
41-2
41-3

41-3500 JOINT TYPE OF CATEGORY E	41-3
41-3600 JOINT TYPE OF CATEGORY F	41-3
41-3700 WELD JOINT BETWEEN NONSTRUCTURAL PART AND	
STIFFENER	41-3
41-4000 WELDED JOINT BETWEEN SECTIONS OF UNEQUAL THIC	CKNESS
	41-3
APPENDIX 51 ULTRASONIC EXAMINATION METHOD	
51-1000 APPLICATION ····	51-1
51-2000 ULTRASONIC EXAMINATION METHOD	51-1
51-2100 EXAMINATION AREA	51-1
51-2200 EXAMINATION PROCEDURE ·····	51-1
51-2300 QUALIFICATION OF EXAMINATION PROCEDURE AND	
QUALIFICATION BLOCK ·····	51-1
51-2400 PROCEDURE OF THE ULTRASONIC EXAMINATION	51-2
51-2500 RECORD	51-2
51-2600 PERSONNEL PERFORMING AND EVALUATING	51-2
51-2700 QUALIFICATION RECORD OF CERTIFIED PERSONNEL ···	51-3
51-2800 ANALYZER	51-3
51-3000 ACCEPTANCE CRITERIA ·····	51-3
51-3100 DATA ANALYSIS CRITERIA ····	51-3
51-3200 INDICATIONS OF GEOMETRIC AND METALLURGICAL O	RIGIN
	51-3
51-3300 FLAW SIZING	51-4
51-3400 FLAW EVALUATION AND ACCEPTANCE CRITERIA	51-4
51-3500 REVIEW	51-5
51-3600 DATA REPORT·····	51-6
SUPPLEMENT I: EDDY CURRENT SURFACE EXAMINATION PRO	CEDURE
REQUIRMENTS	51-15

APPENDIX 1A GUIDELINES FOR QUALITY ASSURANCE
1A-1000 GENERAL PRINCIPLES · · · · 1A-1
1A-1100 APPLICABILITY 1A-1
1A-1200 KEY POINTS OF the QA PROGRAM · · · · 1A-1
1A-2000 GUIDELINES ON APPLICATION OF QUALITY ASSURANCE ··· 1A-2
1A-2100 QUALITY ASSURANCE PROGRAM ····· 1A-2
1A-2100.1 Organization · · · · 1A-2
1A-2100.2 Quality Assurance Program · · · · 1A-4
1A-2100.3 Design Control · · · · 1A-4
1A-2100.4 Procurement Document Control······ 1A-5
1A-2100.5 Instructions, Procedures and Drawings · · · · · 1A-5
1A-2100.6 Document Control
1A-2100.7 Control of Purchased Items and Services · · · · 1A-6
1A-2100.8 Identification and Control of Items · · · · 1A-6
1A-2100.9 Control of Special Processes · · · · 1A-6
1A-2100.10 Inspection · · · · 1A-6
1A-2100.11 Test Control · · · · 1A-6
1A-2100.12 Control of Measuring and Test Equipment · · · · · 1A-7
1A-2100.13 Handling, Storage and Shipping · · · · · 1A-7
1A-2100.14 Inspection, Test and Operating Status······ 1A-7
1A-2100.15 Control of Nonconforming Items · · · · 1A-7
1A-2100.16 Corrective Action · · · · 1A-7
1A-2100.17 Quality Assurance Records · · · · 1A-8
1A-2100.18 Audits · · · · 1A-9
APPENDIX 2A MATERIAL PROPERTIES OTHER THAN YIELD AND TENSILE STRENGTH
2A-100 SCOPE
2A-1000 TOUGHNESS AT CRYOGENIC TEMPERATURES 2A-1
2A-1100 FRACTURE TOUGHNESS VALUE AT TEMPERATURE -269 °C (4K)
2A-1
2A-1200 CHARPY ABSORBED ENERGY AT TEMPERATURE -196 °C (77K) 2A-1

2A-2000 FATIGUE PROPERTIES ·····	· 2A-2
2A-2100 CRACK GROWTH RATE AT TEMPERATURE -269 °C (4K) ····	· 2A-2
2A-3000 OTHER PROPERTIES · · · · · · · · · · · · · · · · · · ·	· 2A-2
2A-3100 MODULUS OF ELASTICITY AT TEMPERATURE -269 °C (4kg	(X) and
-196 °C (77K)····	· 2A-2
2A-3200 AVERAGE LINEAR EXPANSION COEFFICIENTS FROM ROOM	M
TEMPERATURE TO APPROXIMATELY -253 °C (APPROXIMATELY	20K)
	· 2A-3
APPENDIX 3A RULES FOR EVALUATION OF SERVICE CONDIT WITH LIMIT SET WHICH EXCEEDS LIMIT SETS 1, 2 AND 3	IONS
3A-1100 SCOPE	· 3A-1
3A-1200 DESIGN RULES FOR LIMIT SET WHICH EXCEEDS LIMIT SE	ETS 1,
2 AND 3 ····	· 3A-1
3A-1210 GENERAL ····	· 3A-1
3A-1220 DESIGN BY ANALYSIS	· 3A-1
3A-1221 Terms Related to Analysis · · · · · · · · · · · · · · · · · ·	
3A-1221.1 Elastic Analysis · · · · · · · · · · · · · · · · · ·	· 3A-1
3A-1221.2 Inelastic Analysis · · · · · · · · · · · · · · · · · ·	
3A-1221.3 Collapse·····	· 3A-2
3A-1221.4 Plastic Instability Load ······	· 3A-2
3A-1222 Methods and Requirements for Analysis · · · · · · · · · · · · · · · · · ·	· 3A-2
3A-1230 ACCEPTANCE CRITERIA USING ELASTIC ANALYSES ·······	· 3A-3
3A-1231 Criteria for Components · · · · · · · · · · · · · · · · · · ·	· 3A-3
3A-1231.1 Elastic Analysis · · · · · · · · · · · · · · · · · ·	· 3A-3
3A-1231.2 Requirements for Compressive Loads · · · · · · · · · · · · · · · · · · ·	· 3A-3
3A-1232 Criteria for Bolt Connection · · · · · · · · · · · · · · · · · · ·	· 3A-3
3A-1232.1 Allowable Average Stress Intensities · · · · · · · · · · · · · · · · · · ·	· 3A-4
3A-1232.2 Allowable Average Shear Stresses ·····	· 3A-4
3A-1232.3 Maximum Allowable Stress Intensities · · · · · · · · · · · · · · · · · · ·	· 3A-4
3A-1240 ACCEPTANCE CRITERIA USING NON-ELASTIC ANALYSIS	· 3A-4
3A-1240.1 Collapse Load······	· 3A-4

3A-1240.2 Plastic Instability Load ······	····· 3A-4
3A-1240.3 Stress Limit for Bolts ·····	····· 3A-4
APPENDIX 3B FRACTURE MECHANICS EVALUATION	
3B-1000 SCOPE · · · · · · · · · · · · · · · · · · ·	····· 3B-1
3B-1001 Residual Stress ·····	····· 3B-1
3B-1010 GENERAL	····· 3B-1
3B-1100 REQUIREMENTS FOR CRACK SIZE ·····	····· 3B-1
3B-1110 Assumed Initial Crack Size ·····	····· 3B-1
3B-1111 Determination of Assumed Initial Crack Size · · · · · · · · · · · · · · · · · · ·	····· 3B-2
3B 1112 Initial Crack Length for Radiographic Examination	····· 3B-2
3B-1113 Initial Crack Length for Ultrasonic Examination · · · · · · · · · · · · · · · · · · ·	
3B-1114 Initial Crack Length for Magnetic Particle and Liquid	
Examination·····	····· 3B-2
3B-1200 CALCULATION OF CRACK GROWTH RATE ·····	····· 3B-2
3B-1210 CALCULATION OF STRESS INTENSITY FACTOR K_I	····· 3B-3
3B-1220 FAILURE ASSESSMENT ·····	····· 3B-3
3B-1221 Introduction·····	····· 3B-3
3B-1222 Flow Chart of Failure Assessment · · · · · · · · · · · · · · · · · · ·	····· 3B-3
3B-1223 Procedure of Failure Assessment ·····	····· 3B-4
3B-1223.1 Select and Define the Failure Assessment Curve ······	····· 3B-4
3B-1223.2 Failure Assessment Point with Coordinates (L_r', K_r')	····· 3B-5
3B-1223.3 Assessment of Results ·····	
3B-1300 CALCULATED NUMBER OF DESIGN CYCLES ······	····· 3B-7
3B-1310 ALLOWABLE FINAL CRACK DEPTH······	
3B-2000 CALCULATION OF STRESS INTENSITY FACTOR ·······	
3B-2100 SCOPE · · · · · · · · · · · · · · · · · · ·	
3B-2200 CRACK ALLOCATION AND LOADING STRESSES	
3B-2210 CRACK GEOMETRY AND LOADING PATTERNS IN A PL	
3B-2300 DETERMINATION OF STRESS INTENSITY FACTOR IN A	
3B-2310 CASE OF STRESS DISTRIBUTION APPROXIMA	
DOI VNOMINAL EVDDESSION	

3B-2320 CASE OF STRESS DISTRIBUTION	APPROXIMATED BY LINEAR
EXPRESSION ·····	3B-8
3B-3000 REFERECE DOCUMENTS ·····	3B-9
APPENDIX 3C EXPERIMENTAL FATIGUE AN	NALYSIS FOR CYCLIC LOAD