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U. S. NAVAL TECHNICAL MISSION TO JAPAN
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From: Chief, Naval Technical Mission to Japan.
To : Chief of Naval Operations.

Subject: Target Report - Japanese Welding Standards.

Reference: (a) "Intelligence Targets Japan" (DNI) of 4 Sept. 1945.

1. Subject report, covering the metallurigical aspects and methods of welding, and materials and specifications outlined in Target X-36(New) of Fascicle X-1 of reference (a), is submitted herewith.

2. Target X-36(New) was proposed and investigated and the report prepared by Lieut. J.H. Norwood, USNR, assisted by Captain M.S. Zaslow, AUS, as interpreter and translator.

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X-36(N)

JAPANESE WELDING STANDARDS

"INTELLIGENCE TARGETS JAPAN" (DNI) OF 4 SEPT. 1945

FASCICLE X-1, TARGET X-36(N)

NOVEMBER 1945

U.S. NAVAL TECHNICAL MISSION TO JAPAN

SUMMARY

MISCELLANEOUS TARGETS

JAPANESE WELDING STANDARDS

This report covers welding standards in the Japanese Navy, including methods, materials and specifications. In general, the standards in both material and workmanship are decidedly lower than those encountered in U.S. Navy practice. A shortage of materials and skilled labor are contributing factors, but the technical ability of Japanese welding engineers is unquestionably lower than that of their American counterparts. The Japanese Navy did not make the widespread use of welding but restricted its use to limited applications.

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REFERENCES

1. Location of Target:

   KURE Navy Yard, KURE.

   Research Laboratory, MITSUBISHI Heavy Industries Co., Ltd., NAGASAKI Shipbuilding Division.

2. Japanese Personnel Who Assisted in Gathering Documents:

   Captain K. MATSUMOTO, IJN, Chief Designer, KURE Navy Yard.

3. Japanese Personnel Interviewed:

   K. TSUIJI, Welding Engineer, KURE Navy Yard, 14 years' experience, capable engineer.

   Dr. Katsumi OKUDA, Head of Research Laboratory, MITSUBISHI Heavy Industries Co., Ltd., NAGASAKI Shipbuilding Division, 20 years' research experience, very capable.

   Captain I. YATA, IJN, Naval Constructor, SASEBO Navy Yard, 16 years' experience, practical engineer.

LIST OF ENCLOSURES

(A) List of Japanese Documents Concerning Welding Forwarded Through ATIS to WDC Library.

INTRODUCTION

The Japanese Navy has not undertaken welding research to the extent of that done by the U.S. Navy. Riveting was retained as the principal method of construction. The welding actually undertaken by the Japanese is relatively crude by American standards as regards both workmanship and materials. The first all-welded Japanese ship was not constructed until 1933, and it was a light unit. In general the Japanese have not developed a high degree of skill in welding.

THE REPORT

PART I - HISTORY

1. The Japanese first began to use electric-arc welding on ships' hulls and fittings about fifteen years ago. Welding was used only on light construction and metal fittings until 1933. In this year the minelayer YAEYAMA (displacement 1130 tons), the first all-welded naval vessel, was launched. The method of construction and design features of this vessel were exactly the same as if riveting had been used in fabrication. No adaptations or changes were made to accommodate the new fabrication method. Lack of skill in welding the lap joints of the shell plating caused an increase in weight of 3.5% over a riveted sister-ship.

2. The success of the YAEYAMA led to further welding of smaller ships and the welding of minor components of cruisers and destroyers. In 1935 the cruiser MOGAMI was built with a welded hull. Progress in welding had been such that the weight of the MOGAMI was reduced by the use of welding. However, the MOGAMI sprang a leak during its trial run and had to be drydocked for repair and re-enforcement of the defective welds in the shell plating.

3. Despite the MOGAMI's leak, the use of welding was considered a success and its further use approved. The "block" or subsection method of welding was adopted for subsequent construction. Large "blocks" weighed in the neighborhood of 100 tons and were divided into smaller "blocks" of 10 to 35 tons depending on the facilities of the shipyard. All joints in the smaller "blocks" were welded according to specially corrected "block blueprints". Small "blocks" were welded or riveted together to form a large "block" but large "blocks" were always riveted to each other. The block blueprints were designed for easy reading by relatively unskilled workmen. The sequence of construction was indicated on the master blueprint. Since large "blocks" were always riveted to each other, the strength of the joint was that of the riveted connection and was usually designed to be 62% to 77% of the strength of the steel plate in tension.

4. The material of construction of all small ships up through subchasers and destroyer escorts was always medium steel. Destroyers and above of late have been constructed of a low-alloy, high-tensile steel known as Ducol, having a tensile strength of $60kg/mm^2$. No welding was used on this material since no suitable welding electrode had been developed. Late in the war a weldable material similar to the German ST-52 having a tensile strength of $60kg/mm^2$ was used in submarine construction.

PART II - RECENT POLICY ON ARC-WELDING

1. The speed advantage of welding forced the Japanese to use the process during the war years on a more widespread basis than previously. However, welding generally was not used in ship construction for critical applications such as:

a. Main decks (except at the bow and stern)
b. Inner floor plating
c. High tensile steels
d. Non-magnetic steels
e. Armor plating

2. Intermittent welds, except for oil and water-tight joints, were in general usage. The interval measurements for intermittent welds are shown in Table I:

TABLE I
INTERVAL MEASUREMENTS
(Centimeters)

PLATE THICKNESS	LENGTH OF WELD	INTERVAL MEASUREMENTS*				
		1/6	1/5	1/4	1/3	1/2
2.6	20	120			60	
3.0	20		100		60	
5.0	30			120	90	60
8.0	40				120	80
10.0	50				150	100

*Ratio of length of weld to interval.

3. Root openings for continuous welds are shown in Table II:

TABLE II
ROOT OPENINGS IN CONTINUOUS WELDS

PLATE THICKNESS (CM)	10,11	12,14,16	18,20	22 and over
ROOT OPENING (CM)	5	6	7	8

4. On the following applications intermittent welding with ratio of length of weld to interval equal to 1/2 were used:

a. Struts
b. Propeller installations
c. Machinery foundations
d. Gun turrets
e. Around main turrets
f. Around engines and boilers

Otherwise the intermittent welding (ratio - 1/3) were used except on thin bulkheads requiring only low strength joints where the 1/4, 1/5, 1/6 types were used.

5. In general, arc welding was used wherever possible on low-strength joints and used with caution where high strength was required. This is due to the relatively poor electrodes, workmanship, and welding design which the naval constructors were forced to employ.

PART III - SPECIFICATIONS

1. The specifications for mild steel electrodes, which none of the large electrode producers could meet during the war emergency, were quite complete. They include tensile, impact, fatigue, bend, forging, and minimum specific gravity tests as shown in Table III.

TABLE III
TEMPORARY NAVY SPECIFICATIONS
COATED ARC WELDING ELECTRODES FOR MILD STEEL SHIP HULLS,
NOVEMBER 1942

		MILD STEEL PLATE V-SHAPED WELD		ALL WELD METAL	
		Results	No. of Specimens	Results	No. of Specimens
Tensile Test	Min. Tensile Strength Min. Elongation	45kg/mm² 18%	3	41kg/mm² 28	3
Impact Test	Charpy (impact on face of weld)	25kgm	3	30	3
Fatigue Test	Stress limit for $4x10^6$ cycles (min.)	17kg/mm²	3		
Bend Test	800°-900°C 180° bend	No surface imperfections	3		
Forging Test	At 800°-900°C 30x12x200 mm specimen is hammered to thickness of 2mm	No surface imperfections			
Minimum Specific Gravity				7.8	3

2. The specifications for electrode core wire are shown in Table IV below.

TABLE IV
MILD STEEL
ELECTRODE CORE WIRE SPECIFICATIONS
COMPARATIVE TABLE

	C	Mn	Si	P	S	Cw
Japan Standard November 1939	.06 .10	.25 .40	.04 Max	.04 Max	.04 Max	.30 Max
Temporary Japan Standard September 1941 (A)	.06 .12	.25 .40	.04	.04	.04	.30
Temporary Japan Standard September 1941 (B)	.15 Max	.25 .40	.04	.04	.05	.30
Steam Boiler electrodes	.06 .10	.25 .40	.04	.04	.04	.25
Provisional Steam Boiler electrodes	.10 Max	.20 .50	.02	.02	.02	.15

3. The specifications for the Mk 23 electrode used on important structural work, low-alloy and high tensile steels are shown in Table V.

TABLE V

SPECIFICATIONS, Mk 23 ELECTRODE

CHEMICAL COMPOSITION		
	CORE WIRE	FLUX
C	0.10	
Mn	0.30	
Si	0.04	
P	0.04	
S	0.04	
TiO_2		47.0%
SiO_2		2.0
FeO		42.0
Al_2O_3		2.0
CaO		2.0
MgO		3
MnO		2
Cu		0.05

PHYSICAL PROPERTIES		
	ALL WELD METAL	V-SHAPED BUTT JOINT
Tensile Strength	51.8 Kg/mm^2	54.2 Kg/mm^2
Yield Point	43.2 Kg/mm^2	36.9 Kg/mm^2
Elongation	32.5%	18%
Impact (Charpy) value		28.9 Kg-M
Fatigue limit		stress of 17 Kg/mm^2 4,000,000 cycles
Forging test at 800°C		30x12x200mm specimen is hammered to thickness of 2mm without appearance of surface imperfections.

4. Physical property specifications for the large diameter electrodes (3/8" to 3/4") used to speed production are shown in Table VI. The electrodes are the Japanese counterparts of automatic welding in the United States. The chemical composition of the core and flux are the same as those for smaller diameter mild steel electrodes.

TABLE VI

PHYSICAL PROPERTIES - LARGE DIAMETER ELECTRODES

	ALL-WELD METAL	V-SHAPED BUTT JOINTS
Tensile Strength	43 to 47 Kg/mm^2	44 to 54 Kg/mm^2
Yield Point	28 to 33 Kg/mm^2	29 to 35 Kg/mm^2
Elongation	23% to 30%	10% to 12%

The low elongation value is a result of using these electrodes to make single-pass welds in plate thickness up to 1/2-inch. No post-heating was used and the large dendritic crystals formed as a result gave rise to low ductility, a most important deficiency.

PART IV - APPRAISAL

1. Although the quality standards set for welding electrodes are not particularly high, Japanese manufacturers were unable to meet them, even in provisional form. The quality of the workmanship observed was very low, undercutting, irregularity, convexity, and blowholes being readily apparent. X-Ray inspection of submarine hull welds was supposedly in effect. However, the standards of acceptance could not have been high as even the surface imperfections would have been sufficient to disqualify 50% of the welds observed, by United States standards. No pre-heating or post-heating was undertaken. Very little consideration was given to thermal stresses. No wide range of alloy electrodes was developed and no provision was made for electrodes to be used in various positions.

2. All electrodes were of the all-position type and designed to operate on alternating current. Positioning of weldments was undertaken in some cases by means of manual equipment. No automatic positioners with electric or hydraulic control such as are employed in the United States were in use. In the matter of welding design, the size, placement, and sequence of welds, Japanese engineers were not particularly skilful. Unnecessarily large welds, actually stress raisers, were a particularly prevalent fault.

3. To summarize, the quality of Japanese welding is extremely low as evidenced by the failure to meet even provisional electrode specifications, the poor workmanship and design, and the failure to develop a diversified line of electrodes for specific applications. In the engineering and design features of weldments Japanese engineers did not display any great skill.

ENCLOSURE (A)

ENCLOSURE (A)

DOCUMENTS CONCERNING WELDING
FORWARDED THROUGH ATIS TO WDC LIBRARY

1. WELDING REGULATIONS 1939 - NAVTECHJAP DOCUMENT NO. ND50-0001
ATIS DOCUMENT NO. 3015

a. Prices and Controls for Arc Welding Electrodes.
b. Specifications for Steam Boiler Welds.
c. Temporary JAPAN Standards for Electrode Core Wire.
d. Authorized Requirements for Arc Welds - April 1937.
e. Authorized Requirements for Arc Welds - August 1936. MITSUBISHI Heavy Industries Co., Ltd.
f. Standard Requirements for Arc Welding for Ships Construction - September 1942. Navy Technical Department.
g. Standard Specifications for Mild Steel Arc Welding Electrode for Engine Manufacture - April 1939. Navy Technical Department.
h. Japanese-English Technical Vocabulary of Welding Terminology.
i. Provisional Specifications for Arc Welds on Machinery - March 1936.
j. Provisional Qualifications for Navy Shipyard Welders - May 1942. MAIZURE Navy Yard.
k. One set photomicrographs showing standards for welds on internal combustion engines.
l. Lloyds Regulations for Arc Welding in Ship Construction.
m. Provisional Specifications for Welding Pressure Vessels.
n. Tests for Stationary Steamboilers MITSUBISHI Heavy Industry.
o. Bibliography of papers on arc welding in steel construction.
p. Long Large Diameter Welding Electrodes and Automatic Welding.

2. BLUE-PRINTED PAMPHLETS - NAVTECHJAP DOCUMENT NO. ND22-0020-0028
ATIS DOCUMENT NO. 3016

a. Historical Development of Electric Arc Welding in Imperial Japanese Navy.
b. Test Results (Slag Type Electrode)
c. Test Results (Large Diameter Electrode)
d. Test Results (Armor Plate Electrode)
e. Test Results (Thin Gauge Electrode)
f. Rules for Welding Inspection
g. Practical Welding Applications