

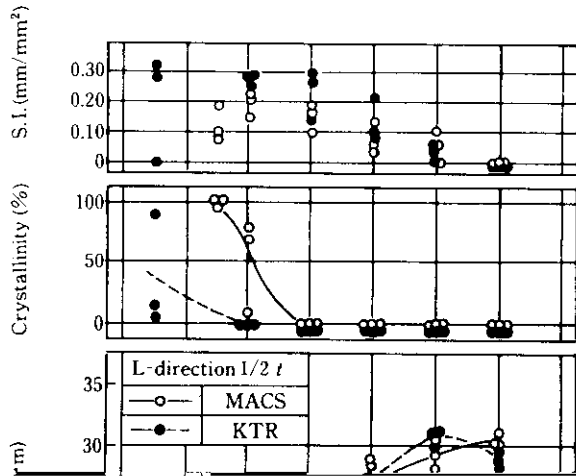
Structural Steel Plates for Arctic Use Produced by Multipurpose Accelerated Cooling System*

Synopsis:

Table 1 Chemical compositions of steels for YP 36 kgf/mm² arctic use produced by MACS and KTR (wt%)

Element	MACS	KTR
C		
Mn		
P		
S		
Si		
N		
Al		
Fe		
Cr		
Ni		
Mo		
Cu		
Co		
As		
Sb		
Bi		
Se		
Te		
Ag		
Au		
Cd		
Ce		
Pr		
Nd		
Sm		
Eu		
Gd		
Tb		
Dy		
Ho		
Er		
Tm		
Yb		
Lu		
Hf		
Zr		
Nb		
Ta		
V		
Cr		
Mn		
Fe		
Ni		
Cu		
Zn		
Al		
Mg		
Ca		
Na		
K		
Li		
B		
F		
Cl		
Br		
I		
At		
Pb		
Bi		
Po		
At		
Rn		
Fr		
Ra		
Ac		
Th		
Pa		
U		
Np		
Pu		
Am		
Cm		
Bk		
Cf		
Es		
Fm		
Mendelevium		
Nobelium		
Lanthanum		
Cerium		
Praseodymium		
Neodymium		
Europium		
Gadolinium		
Terbium		
Dysprosium		
Ytterbium		
Lutetium		
Scandium		
Titanium		
Vanadium		
Chromium		
Manganese		
Iron		
Cobalt		
Nickel		
Copper		
Zinc		
Galium		
Germanium		
Arsenic		
Selenium		
Bromine		
Krypton		
Rubidium		
Strontium		
Yttrium		
Zirconium		
Niobium		
Molybdenum		
Technetium		
Ruthenium		
Rhodium		
Palladium		
Silver		
Cadmium		
Indium		
Tin		
Antimony		
Tellurium		
Iodine		
Xenon		
Cesium		
Barium		
Lanthanum		
Cerium		
Praseodymium		
Neodymium		
Europium		
Gadolinium		
Terbium		
Dysprosium		
Ytterbium		
Lutetium		
Hafnium		
Tantalum		
Tungsten		
Rhenium		
Osmium		
Iridium		
Platinum		
Gold		
Mercury		
Thallium		
Lead		
Bismuth		
Polonium		
Astatine		
Radon		
Francium		
Radium		
Actinium		
Thorium		
Protactinium		
Uranium		
Neptunium		
Plutonium		
Americium		
Curium		
Berkelium		
Californium		
Einsteinium		
Fermium		
Mendelevium		
Nobelium		
Lanthanum		
Cerium		
Praseodymium		
Neodymium		
Europium		
Gadolinium		
Terbium		
Dysprosium		
Ytterbium		
Lutetium		
Scandium		
Titanium		
Vanadium		
Chromium		
Manganese		
Iron		
Cobalt		
Nickel		
Copper		
Zinc		
Galium		
Germanium		
Arsenic		
Selenium		
Bromine		
Krypton		
Rubidium		
Strontium		
Yttrium		
Zirconium		
Niobium		
Molybdenum		
Technetium		
Ruthenium		
Rhodium		
Palladium		
Silver		
Cadmium		
Indium		
Tin		
Antimony		
Tellurium		
Iodine		
Xenon		
Cesium		
Barium		
Lanthanum		
Cerium		
Praseodymium		
Neodymium		
Europium		
Gadolinium		
Terbium		
Dysprosium		
Ytterbium		
Lutetium		
Hafnium		
Tantalum		
Tungsten		
Rhenium		
Osmium		
Iridium		
Platinum		
Gold		
Mercury		
Thallium		
Lead		
Bismuth		
Polonium		
Astatine		
Radon		
Francium		
Radium		
Actinium		
Thorium		
Protactinium		
Uranium		
Neptunium		
Plutonium		
Americium		
Curium		
Berkelium		
Californium		
Einsteinium		
Fermium		
Mendelevium		
Nobelium		
Lanthanum		
Cerium		
Praseodymium		
Neodymium		
Europium		
Gadolinium		
Terbium		
Dysprosium		
Ytterbium		
Lutetium		
Scandium		
Titanium		
Vanadium		
Chromium		
Manganese		
Iron		
Cobalt		
Nickel		
Copper		
Zinc		
Galium		
Germanium		
Arsenic		
Selenium		
Bromine		
Krypton		
Rubidium		
Strontium		
Yttrium		
Zirconium		
Niobium		
Molybdenum		
Technetium		
Ruthenium		
Rhodium		
Palladium		
Silver		
Cadmium		
Indium		
Tin		
Antimony		
Tellurium		
Iodine		
Xenon		
Cesium		
Barium		
Lanthanum		
Cerium		
Praseodymium		
Neodymium		
Europium		
Gadolinium		
Terbium		
Dysprosium		
Ytterbium		
Lutetium		
Hafnium		
Tantalum		
Tungsten		
Rhenium		
Osmium		
Iridium		
Platinum		
Gold		
Mercury		
Thallium		
Lead		
Bismuth		
Polonium		
Astatine		
Radon		
Francium		
Radium		
Actinium		
Thorium		
Protactinium		
Uranium		
Neptunium		
Plutonium		
Americium		
Curium		
Berkelium		
Californium		
Einsteinium		
Fermium		
Mendelevium		
Nobelium		
Lanthanum		
Cerium		
Praseodymium		
Neodymium		
Europium		
Gadolinium		
Terbium		
Dysprosium		
Ytterbium		
Lutetium		
Scandium		
Titanium		
Vanadium		
Chromium		
Manganese		
Iron		
Cobalt		
Nickel		
Copper		
Zinc		
Galium		
Germanium		
Arsenic		
Selenium		
Bromine		
Krypton		
Rubidium		
Strontium		
Yttrium		
Zirconium		
Niobium		
Molybdenum		
Technetium		
Ruthenium		
Rhodium		
Palladium		
Silver		
Cadmium		
Indium		
Tin		
Antimony		
Tellurium		
Iodine		
Xenon		
Cesium		
Barium		
Lanthanum		
Cerium		
Praseodymium		
Neodymium		
Europium		
Gadolinium		
Terbium		
Dysprosium		
Ytterbium		
Lutetium		
Hafnium		
Tantalum		
Tungsten		
Rhenium		
Osmium		
Iridium		
Platinum		
Gold		
Mercury		
Thallium		
Lead		
Bismuth		
Polonium		
Astatine		
Radon		
Francium		
Radium		
Actinium		
Thorium		
Protactinium		
Uranium		
Neptunium		
Plutonium		
Americium		
Curium		
Berkelium		
Californium		
Einsteinium		
Fermium		
Mendelevium		
Nobelium		
Lanthanum		
Cerium		
Praseodymium		
Neodymium		
Europium		
Gadolinium		
Terbium		
Dysprosium		
Ytterbium		
Lutetium		
Scandium		
Titanium		
Vanadium		
Chromium		
Manganese		
Iron		
Cobalt		
Nickel		
Copper		
Zinc		
Galium		
Germanium		
Arsenic		
Selenium		
Bromine		
Krypton		
Rubidium		
Strontium		
Yttrium		
Zirconium		
Niobium		
Molybdenum		
Technetium		
Ruthenium		
Rhodium		
Palladium		
Silver		
Cadmium		
Indium		
Tin		
Antimony		
Tellurium		
Iodine		
Xenon		
Cesium		
Barium		
Lanthanum		
Cerium		
Praseodymium		
Neodymium		
Europium		
Gadolinium		
Terbium		
Dysprosium		
Ytterbium		
Lutetium		
Hafnium		
Tantalum		
Tungsten		
Rhenium		
Osmium		
Iridium		
Platinum		
Gold		
Mercury		
Thallium		
Lead		
Bismuth		
Polonium		
Astatine		
Radon		
Francium		
Radium		
Actinium		
Thorium		
Protactinium		
Uranium		
Neptunium		
Plutonium		
Americium		
Curium		
Berkelium		
Californium		
Einsteinium		
Fermium		
Mendelevium		
Nobelium		
Lanthanum		
Cerium		
Praseodymium		
Neodymium		
Europium		
Gadolinium		
Terbium		
Dysprosium		
Ytterbium		
Lutetium		
Scandium		
Titanium		
Vanadium		
Chromium		
Manganese		
Iron		
Cobalt		
Nickel		
Copper		
Zinc		
Galium		
Germanium		
Arsenic		
Selenium		
Bromine		
Krypton		
Rubidium		
Strontium		
Yttrium		
Zirconium		
Niobium		
Molybdenum		
Technetium		
Ruthenium		
Rhodium		
Palladium		
Silver		
Cadmium		
Indium		
Tin		
Antimony		
Tellurium		
Iodine		
Xenon		
Cesium		
Barium		
Lanthanum		
Cerium		
Praseodymium		
Neodymium		
Europium		
Gadolinium		
Terbium		
Dysprosium		
Ytterbium		
Lutetium		
Hafnium		
Tantalum		
Tungsten		
Rhenium		
Osmium		
Iridium		
Platinum		
Gold		
Mercury		
Thallium		
Lead		
Bismuth		
Polonium		
Astatine		
Radon		
Francium		
Radium		
Actinium		
Thorium		
Protactinium		
Uranium		
Neptunium		
Plutonium		
Americium		
Curium		
Berkelium		
Californium		
Einsteinium		
Fermium		
Mendelevium		
Nobelium		
Lanthanum		
Cerium		
Praseodymium		
Neodymium		
Europium		
Gadolinium		
Terbium		
Dysprosium		
Ytterbium		
Lutetium		
Scandium		
Titanium		
Vanadium		
Chromium		
Manganese		
Iron		
Cobalt		
Nickel		
Copper		
Zinc		
Galium		
Germanium		
Arsenic		
Selenium		
Bromine		
Krypton		
Rubidium		
Strontium		
Yttrium		
Zirconium		
Niobium		
Molybdenum		
Technetium		
Ruthenium		
Rhodium		
Palladium		
Silver		
Cadmium		
Indium		
Tin		

Table 4 Results of three point bending test



Process	Direction	Temp. (°C)	Critical COD (mm)	
MACS (ACC)	L	-40	2.039,	1.752
		-60	1.630,	1.666
		-80	1.690,	1.667
	T	-40	1.509,	1.618
		-60	1.391,	1.413
		-80	1.378,	1.157
KTR	L	-40	2.215,	2.437
		-60	2.058,	2.346
		-80	2.115,	2.225
	T	-40	2.122,	1.355
		-60	2.072,	1.658
		-80	1.467,	1.419

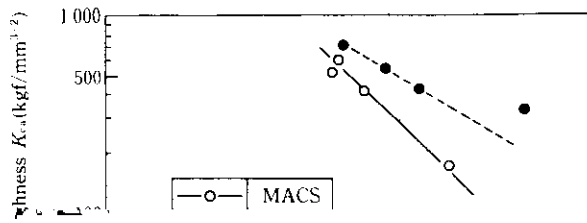


Table 7 Tensile test results at high heat input welding joint of steel plates produced by MACS process

Welding	TS (kgf/mm ²)	Fracture location
One side	54.9	RM



any welding process, thickness level and notch position.

As shown in Fig. 4, the individual values of charact...

Table 9 Results of wide-width center-notched tensile test under residual stress for brittle fracture

process were tested. As a result, it was proved that the said steel plates can be welded without reheat-

74