APPENDIX D:

TRAINING MATERIALS OF TOT

Appendix D: Training Materials of ToT

D-1. Welding

D-1-1. Safety & Health

Welding Processes

Arc

- Shield metal arc welding
- Semi-automatic arc welding (GMAW)
- Gas tungsten arc welding (TIG)
- Metal inert-gas welding

Gas flame

- Oxy-fuel gas cutting & welding
- Brazing with filler metal

Safe & Health

4.1 Protect Clothing

Welder and other worker must be worn protective goods during their operation as follow

① : a cap, especially at the high location
② : Cuff-less pants & Flaps on shirt pockets
③ : Clean clothing without dust and grease
④ : Sturdy shoes

＊ Prohibit to wear necktie, towel and scarf and to operate with bare foot or sandal

Protected clothing & apparatus

Electric shock (1)

(Recognition of hazards)

① : Switch on or switch off the electrified cable
② : Isolated treatment on the bared portion
③ : Hazard guide

Described items

- Content of guide
- Reason of hazard
- Signature of supervisor

Electric Hazard (2)

(Voltage & safety distance)
To not approach the electric circuit without grounding and keep the safety distance refer to table1 as bellow

Table 1 Safety distance

Voltage	Distance
750 V ~ 2,500 V	0.3m
2,500 V ~ 10,000 V	0.6m
10,000 V ~ 50,000 V	1.1m
50,000 V ~100,000 V	1.5m

Electric Shock (3)

Shock severity depend on the amount, duration and path of current, and also depend on the physical condition of victim.

Electric resistance at parts of body

On the skin : 2,500Ω
(wetted by heavy persolration : 1,000Ω)

Whole of body : 300 Ω (Very low !)

between foot and shoes : 1,500Ω

between shoes and ground : 2500Ω

(in wet environment : 500Ω)

Electric shock (4)

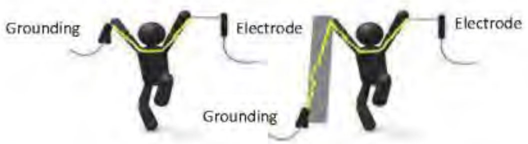
Electric resistance of the human body are very low, therefore the current is easy to pass through the body
(Example)
No-load voltage: E=95V, **Electric resistance :** R=10,000
Current: *I=E/R=95/10,000 ≒ 0.01A ⇒ 10mA*

Current	Indication
1mA	Feeling of electrify
5 mA	Pain
10mA)	Untolerable ache
20 mA	Impossible to remove the gripped cable by oneself
50 mA)	Dangerous state
100mA	

Portion	state	Max (Ω)	Min (Ω)
Hand-Hand	Dry	18,000	6,600
ditto	Wet	2,720	930
Hand-Foot	Dry	13,500	1,550
ditto	Wet	1,260	610

Electric shock (5)

[1] Main factor
- ① : Damage of cable (bad insulation)
- ② : Breakage of insulated electrode holder
- ③ : Bad insulated state on weld equipment
- ④ : Heavy perspiration・wetted clothing
- ⑤ : Operation in confined space
- ⑥ : Touch on the lectrode



Electric shock (6)

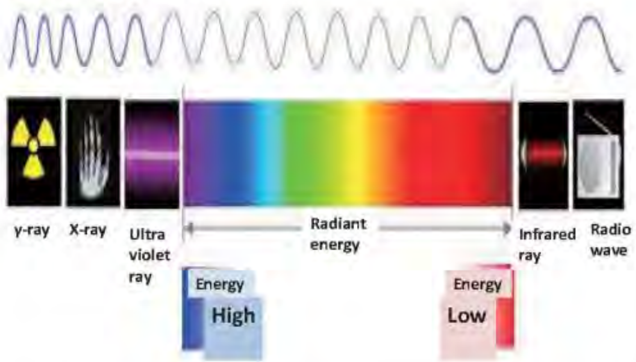
[2] Countermeasure
- ① : Proper cable & connection
- ② : Insulated electrode holder
- ③ : Grounding the chassis of weld machine
- ④ : leather grove
- ⑤ : Open circuit of welding power in work-off
- ⑥ : Voltage reducing device
- ⑦ : Avoidance from the exposure of body
- ⑧ : Grounding the base metal or operating table

Electric shock (7)

[3] Someone has suffered electric shock
- ① : Cut-off the electric source immediately
- ② : No time to cut-off ;
  Separate the victim from electrifying object using of well-insulated materials
  (dry gloves must be put on, prohibit bare hand)
- ③ : Waiting for medical help
- ④ : Artificial respiration (continue)

Radiation

(Frequency band)



A-36

Eye and face protection (1)

[1] <u>Ultraviolet rays</u>

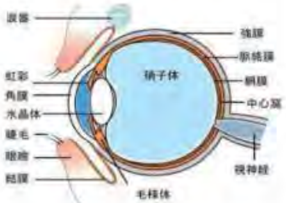
①： Painful ophthalmia（incubated time ~ 0.5−24 hour）
②： Burns on the skin
③ : Reduction of eye sight due to exposure for long time

[2] <u>Radiant energy / Visible light</u>

very strong , so caused the temporarily blindness

[3] Infrared radiation

Reduction of eye sight
due to exposure for long time



Eye and face protection (2)

(Face shield)

JIS T 8142:2003

Kind	model		記号
Helmet shield	Head band type	Open-Close	EH-1
		Fixed	EH-2
	cap attachment type	Open-Close	ES-1
		Fixed	ES-2
Hand shield	−	Open-Close	F-1
		Fixed	F-2



Eye and face protection (3)

<u>Protection material</u>

Shield glasses


Protective screen

① : Filtering of harmful radiation
(a) Strong light, (b) Violet ray, (c)Infrared ray
② : Protect from the flying spatter and slag
③ : Protect from the heat

Protection from fumes and harmful gasses (1)

[1] The amount of fumes

Preliminary particle: 0.1 μm
Secondary cohered particle: 1 μm
＊ Harmful range : 0.5 ~ 5 μm

Welding process	Dia. (mm)	Current (A)	Amount of fumes		
			mg/min	mg/filer metal (g)	mg/DM(g)
SMAW	4.0	170	292	7.0	11.2
CO_2 GMAW	1.6	400	598	5.2	5.4
Self-shield arc welding	3.2	400	2000~3500	16~28	23~41
SAW	6.4	1200	40	−	0.1

Protection from fumes and harmful gasses (2)

[2] Fume damage for human body

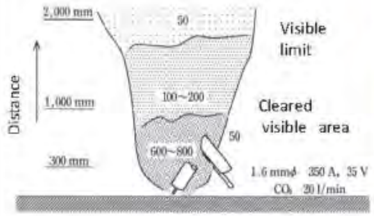
Quick symptom： 「metal fever」
lazy, joint pain, shake, increase breath or pulse, sickness, head ache, cough, perspiration etc.,
Chronic symptom： 「pneumoconiosis」
In general, less of consciousness

Protected methods for fumes
- Ventilation system (Local or whole)
- Mask with filter / applied-air respirator
- Preparation of rest room
- Cleaning of the work area
- Periodically medical check

Protection from fumes and harmful gasses (3)

[3] Harmful gas (CO: carbon oxidation)
Chemical reaction: $CO_2 \rightarrow CO + O$

Acceptable limit： 50ppm

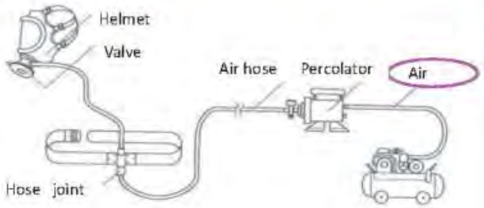


CO gas density at the arc point

Local ventilation

Protection from fumes and harmful gasses (4)

Applied-air respirator



Suitable Oxygen for life support
(at least 18 volume %)

Explosion and fire (1)

(1) Combustible & explosive material

oils, paints, solvent, wood, textiles, powder dust, etc.,
must be removed from operated area

Explosion and fire (2)

(2) Flammable liquid propellant & gasses

Prior to welding or cutting work at the area such as tank, pipe and vessel, the absence of dangerous materials must be confirmed

Precautions for work at high locations (1)

(Protection of falling)

① Proper clothing and safety equipment. Use a safety belt

② Voltage reducing device (AC arc welding process)

③ Investigate surrounding area. Avoid dangerous attitudes

④ Do not wear slippery shoes. Special attention must be paid in rain, strong wind, snow condition

⑤ Tools and materials on a scaffold should be secured with a cord to placed in stable locations

⑥ Prior to work, confirm the stability of ladders, scaffolds, Handrails etc.,

Precautions for work at high locations (2)

⑦ Working on a scaffold

(a) Do not alter or move scaffolds or footing boards without permission

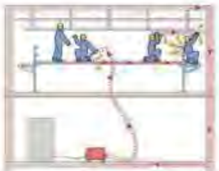
(b) Do not over weight items on scaffolds

(c) Do not run or jump

(d) Do not stand up suddenly after sitting at work for long periods

(e) Do not place too many persons on footing board

(f) Always keep the work area clean



D-1-2. Basic skill Training of GMAW (MAG)

炭素鋼Gas-shield arc welding for plain carbon steel

Basic skill training of GMAW(MAG)

Japan welding technology center

Preperation for weld skill training

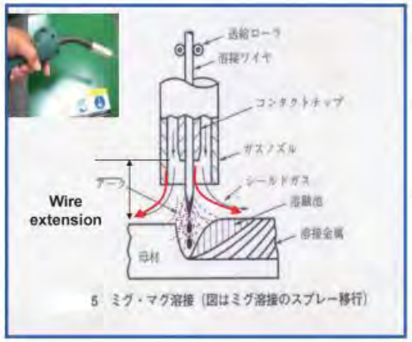
Code of filler wire (Japan)	Shield gas	Note
YGW11,12,13,14	CO_2 gas	ordinary type
YGW15 YGW16 YGW17	80 Ar-20 CO_2	
YGW18	CO_2 gas	for high strength steel & high heat input
YGW19	80Ar-20 CO^2	

Tool for skill training

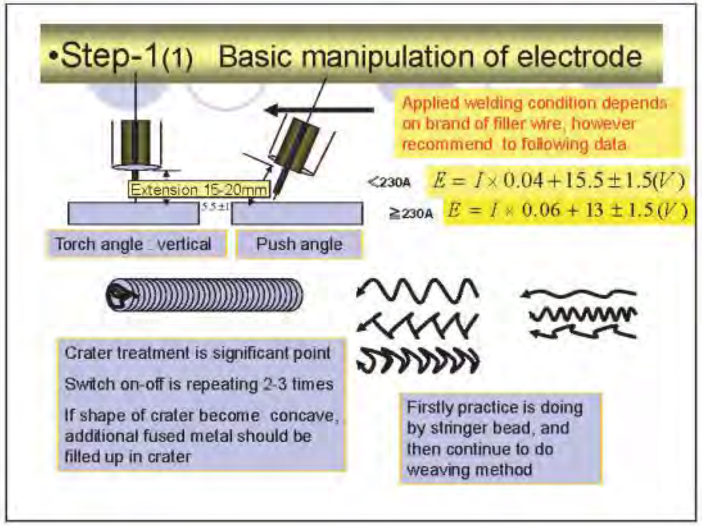
Check points on the welding operation

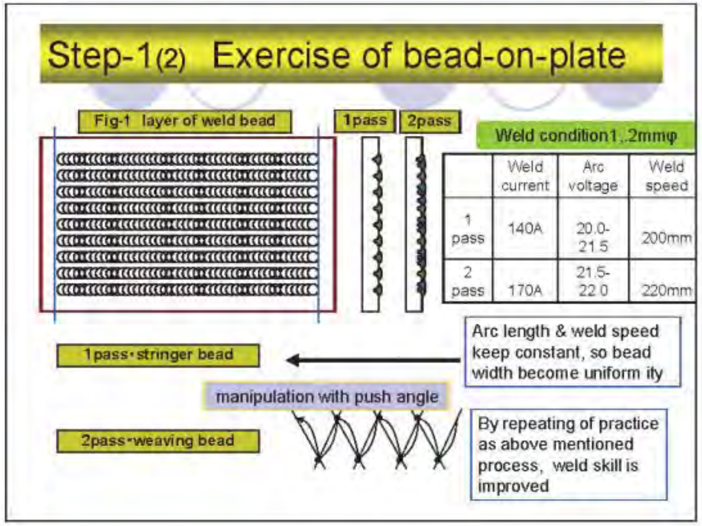
- ◎ the suitable condition for welding operation
- ◎ Cleanness of welding clothes & protected goods
  - Put on standard filter glass (#11.#12)
- ◎ maintenance of protected goods
- ◎ tidy on operational space
- ◎ provisions for ventilation & shading
- ◎ checking of welding installation & tools
- (shielding gases , welding materials so on)
- ◎ good physical condition

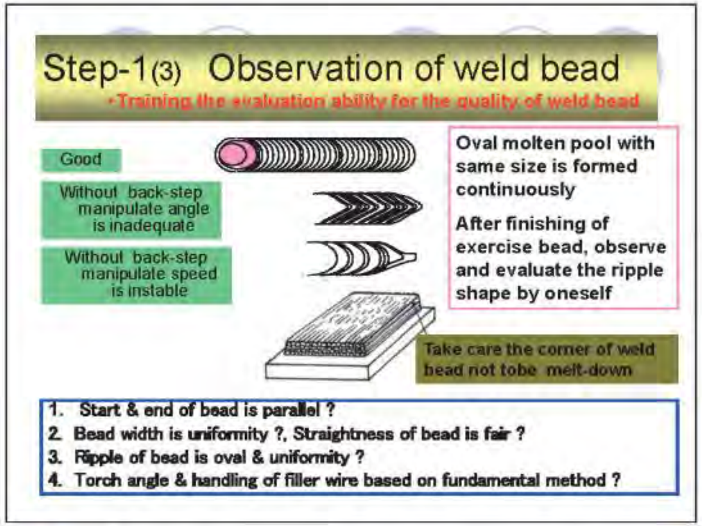
Outline of GMAW process

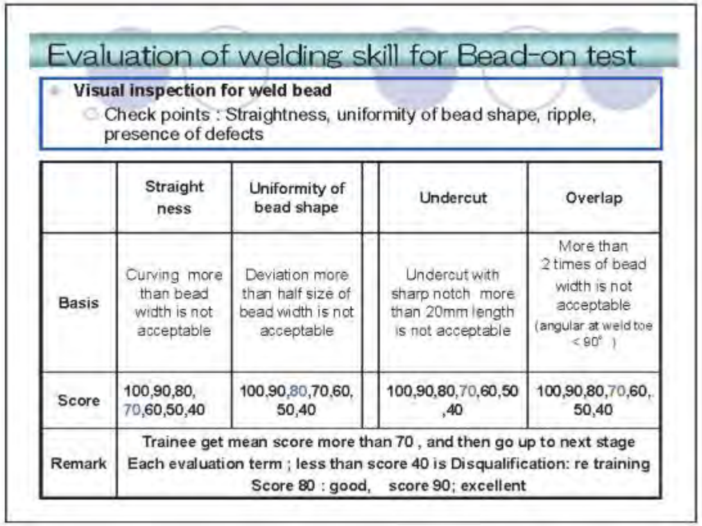


Basic item		
Filler wire	Solid type 1.2mmφ	
Gas flow rate	15-20 ℓ/min	
Wire extension	15-25mm	









Evaluation of welding skill for Bead-on test

- **Visual inspection for weld bead**
  - Check points : Straightness, uniformity of bead shape, ripple, presence of defects

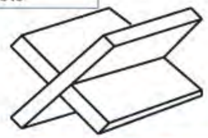
	Straight ness	Uniformity of bead shape	Undercut	Overlap
Basis	Curving more than bead width is not acceptable	Deviation more than half size of bead width is not acceptable	Undercut with sharp notch more than 20mm length is not acceptable	More than 2 times of bead width is not acceptable (angular at weld toe < 90°)
Score	100,90,80, 70,60,50,40	100,90,80,70,60, 50,40	100,90,80,70,60,50 ,40	100,90,80,70,60, 50,40
Remark	Trainee get mean score more than 70 , and then go up to next stage Each evaluation term ; less than score 40 is Disqualification: re training Score 80 : good, score 90; excellent			

Step-2(1) Flat position fillet welding

Preparation

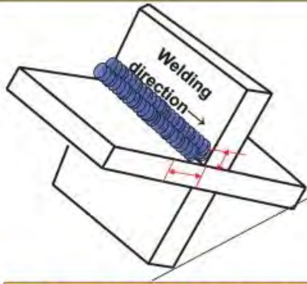
- Welding material
  (Solid wire ; refer to table)
  Dia. Of filler wire 1.2mmφ
- Steel plate (mild steel)
  gauge 8～12mmt
  75×200mm 2 sheets、
  150×200mm 1 sheets

Code	Shield gas	Note
YGW11, 12,13,14	(CO_2)	Mild steel
YGW15 YGW16 YGW17	(80Ar-20 CO_2)	High strength steel 490N/mm2



Preparation of cruciform joint specimen

Step-2(2) Exercise of flat position fillet welding



Welding condition1.2mmφ

	Weld current	Arc voltage	Weld speed
1 pass	170A	21.5-22.5	220mm
2 Pass ～	200A-230A	22.0-24.0	220-280mm

1. Electrode manipulation is similar as bead-on-plate
2. In order to gain the mitre fillet weld, stringer bead and weaving bead must be combined. Also bead surface become flat as well as posible
3. Incomplete penetration & lack of fusion do not occur at the start & end of weld bead

Step-2(3) Check the quality of weld bead

- **To evaluate the weld bead and multi-pass layer state based on the skill evaluation list of bead-on-plate.**
- **In the case of good score , go to next stage**
- **Basic skill training composed of step 1 & step 2.**

『welding position, torch angle, arc length, electrode manipulation and etc. must be checked again.

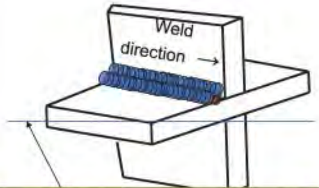
Feeling of welding speed is significant.

Trainee must be gain proper feeling concerning with welding speed』

Step-3(1) Exercise of horizontal fillet welding

Weld condition1.2mmφ

	Weld current	Arc voltage	Weld speed
1 pass	170A	21.5-22.5	220mm
2 Pass ～	170A-200A	21.5-23.0	220-280mm



Cruciform joint specimen is inserted into opening site of working table

To do practice with watching the relationship between each welding factor and quality of weld bead

1. Incomplete penetration & lack of fusion do not occur at the start & end of weld bead
2. In order to gain the mitre fillet weld, stringer bead and weaving bead must be combined. Also bead surface become flat as well as posible

Step-3(2) Exercise of horizontal fillet welding with multi-pass

Buildup is conducted by forehand welding with 80-70° push angle as shown upper figure
Torch angle is basically 35-45° ,it must be changed according to weld on horizontal plate or vertical plate.
Repeating practice with watching the quality of each weld bead is essential.
Welding with 1pass can be formed weld bead with 8mm fillet leg & fine appearance
In order to get large fillet leg, multi-pass welding must be applied.
Welding with large fillet leg by 1 pass bead is not acceptable caused to occurrence of many defects

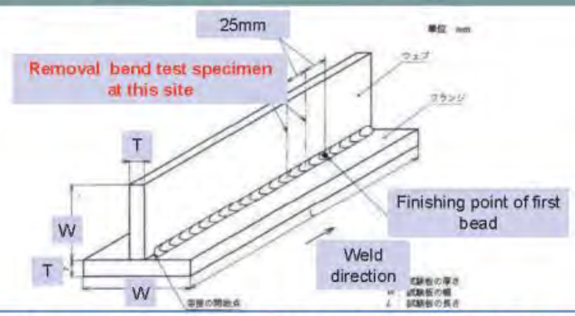
Step-3(3) Check the quality of weld bead

- To evaluate the weld bead , multi-pass layer state and fillet leg based on the skill evaluation list of bead-on-plate.
- In the case of good score , go to next stage
- Step 3 is first progressed level.
- In order to judge one's skill, adoption of macro-structure test is recommended.

【welding position, torch angle, arc length, electrode manipulation and etc. must be checked again.
Feeling of welding speed is significant.
Trainee must be gain proper feeling concerning with welding speed】

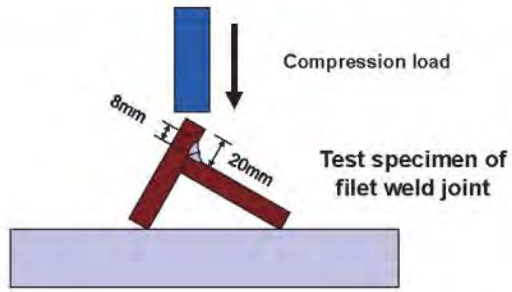
Step-4(1) Bending test of fillet welding

Specimen of fillet welding joint



Compact test ; to break the whole joint, and then inspect the fractured surface

Compact bending test for filet weld joint



Evaluation method for filet weld joint

Kind of imperfection	Acceptable size (ISO 5817 Level B)
cracks	Not acceptable
Gas pocket & dispersed porosity	The total sum of imperfection should be less than 1% of observed area and also the size of independent imperfection should be less than 3mm.
Gathered porosity	The total sum of imperfection should be less than 4% of observed area and also the size of independent imperfection should be less than 3mm.
Elongated pore & warm hole	The size (height & width) of imperfection should be less than 2mm.
Inclusion (steel)	The length of imperfection along welding direction should be less than 25mm.
Inclusion (other metal)	The size (height & width) of imperfection should be less than 2mm.
Lamination	Not acceptable
Lack of fusion	
Incomplete penetration	

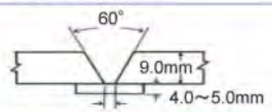
Supplement

ステップ5. S-5(1.1) 下向突合せ溶接 (裏当て金付き)

準備する資材

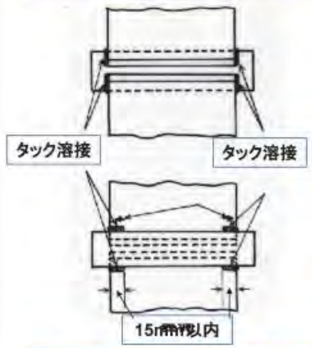
- 溶接材料
  ソリッドワイヤ 右表より選定
  ワイヤ径1.2mmφ
- 軟鋼鋼板
  a. 9.0mmt **100×150mm(30° ベベル角)**
  b. 裏当て金 4~6mmt
  30mm×180mm

ワイヤの種類	適用シールドガス	主な鋼種
YGW 11,12, 13,14	炭酸ガス (CO_2)	軟鋼及び引張強さ490N/mm² 級高張力鋼
YGW 15 YGW 16 YGW 17	80%アルゴン-20%炭酸ガス (80Ar-20 CO_2)	

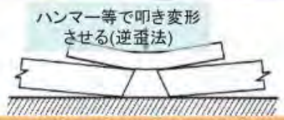


突合せ溶接(裏板金あり)

S-5(1.2) 下向突合せ溶接
試験体の組立準備



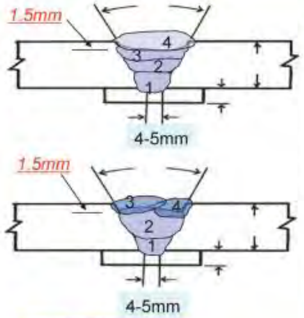
仮付け冶具に挟んで、裏当て金と試験板に隙間が無いように、タック溶接



溶接を行うと、試験片は3° ~6° の変形を生ずる。

溶接前に裏当て金を変形させ、逆歪を取る

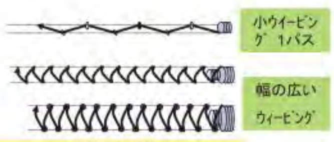
S-5(2)　下向突合せ溶接



積層要領

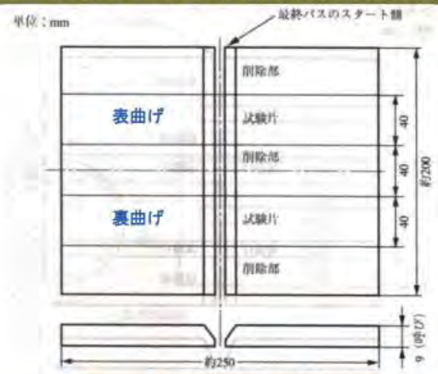
1.2mmφの溶接条件例

溶接条件	溶接電流 (A)	アーク電圧 (V)	溶接速度 (mm/min)
全パス	140-180	20.5-21.5	約 220-280
最終パスが1パスの場合	180-230	21.5-23.0	約 190-260



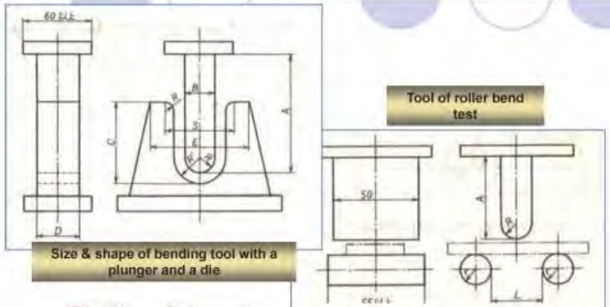
基本運棒

S-5(3) 中板突合せ継手の曲げ試験
曲げ試験片の採取方法(日本規格)



曲げ試験片の採取位置

Reference book
mechanical test for weld joint (JIS Z 3122)



R(radius of plunger)

= 2 times of specimen thickness

Remark: R : decide due to material

L : 2R + 2t +3

(t= thickness of test specimen)

A : more than 5R+80

r : more than 20

S-5(4)　評価試験と資格判定基準

- 学科試験・・・・・60点以上を合格
- 実技/外観試験・・・・・①ビード形状　②溶接の始端及び終端の状況　③裏波溶接の場合は溶込み状況　④アンダカット、オーバラップ及びピットの状況を判断し、著しく不良のものは不合格とする

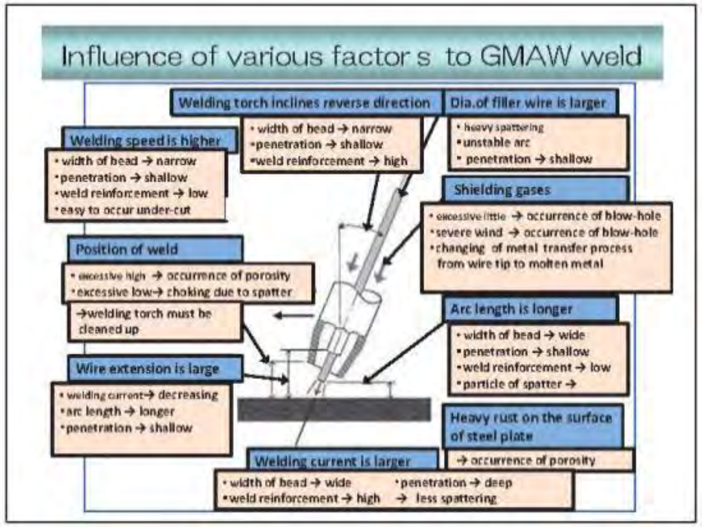
- 曲げ試験(合否判断)

曲げ試験は前項の冶具を使用し180°曲げを実施。

以下の状態を不合格とする。

- 3.0mmを超える割れが存在する場合。
- 3.0mm以下の割れが合計7mmを超えた場合。
- 0.5mm以下の割れは10個を超えた場合。
- ビード表面のアンダカット及び欠陥は合計長さが試験片の幅の長さを超えた場合。

D-1-3. Influence of Various Factor to GMAW



D-1-4. Testing Sample of Welding Education

Test Sample for Weld Education

Japan Welding Technology Center

Kind of test sample for weld education

(Composition of three part)

- Part 1: Macro-structure specimens of main weld defect
- Part2: Visual test specimens (Inspection)
- Part3: Judgment of bending test

Macro-structure specimens of weld defect

No.	Defect on surface name	No.	Defect in inside name
1	Incomplete penetration	6	Lack of fusion
2	Undercut	7	Blowhole
3	Weld joint mismatch	8	Slag inclusion
4	Excessive reinforcement of weld	9	Hot crack
5	Excessive backing bead	10	Cold crack

Note) If crack go through steel plate, it can be observed on the surface

Incomplete of penetration

Under cut

Weld joint mismatch

Excessive backing bead

Excessive backing bead

Lack of fusion

Blowhole

Slag inclusion

Hot crack

Cold crack

Kind of test sample for weld education

(Composition of three part)

- Part 1: Macro-structure specimens of main weld defect
- Part2: Visual test specimens (Inspection)
- Part3: Judgment of bending test

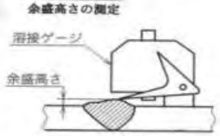
Various kind of visual test sample

No	Name	No	Name
0	Shortage reinforcement	6	Crack
1	Excessive reinforcement	7	Pit
2	Incomplete of weld bead	8	Incomplete penetration
3	Weld joint mismatch	9	Undercut
4	Convex fillet weld	10	Overlap
5	Angular distortion	11	Arc strike

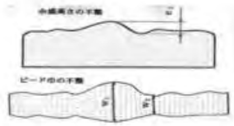
Reinforcement of weld (excessive or convexity)

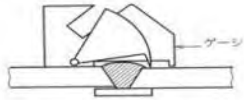
No.4 Sample

No.1 Sample



Incomplete of weld bead (No.2) Weld joint mismatch (No.3)

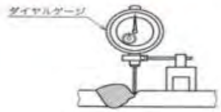




溶接ゲージによる
目違いのチェック

Pit (No.7)& Incomplete penetration(No.8)

Undercut (No.9) & Overlap (No.10)

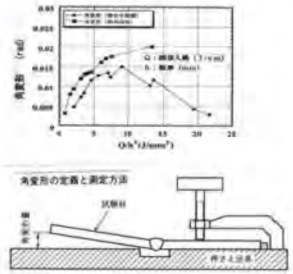


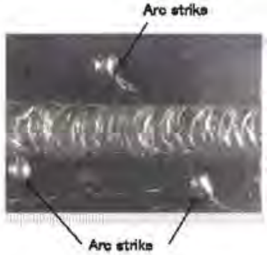
ダイヤルゲージによる
アンダカットのチェック

オーバラップ：フランク角θが
90°未満の状態をいう。

オーバラップの定義（θ：フランク角）

Angular distortion (No.5)
Arc strike (No.11)





Kind of test sample for weld education

(Composition of three part)

- Part 1: Macro-structure specimens of main weld defect
- Part2: Visual test specimens (Inspection)
- Part3: Judgment of bending test

Evaluation method of bend test

Purpose of bend test : Check of weld joint soundness

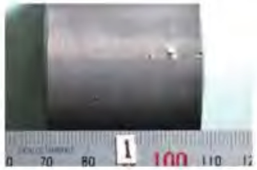
(1) Observe on the surface of bending specimen
(2) Confirm the existence of weld defect, discontinuity and imperfection.
(3) Study their kind, occurrence site, size, and number
(4) Record & Judgment

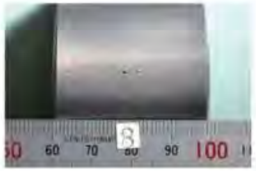
Note: Observation method
~ ordinary by using naked eye and occasionally by using lope (x10) as a complementary means

Example of acceptance result

No.	Cause of judgment
1	Length of each independent broken part is less than 3mm, and added length of total cracks is not more than 7mm
3	Total length of Incomplete penetration & slag inclusion on one side of weld line is less than 13mm
5	Total length of undercut on one side of weld line is less than 13mm
8	Total number of hole with 0.2mm dia. is less than 10

Observation of bend test (Acceptance)

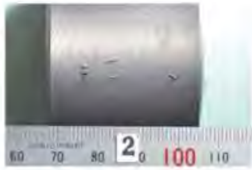


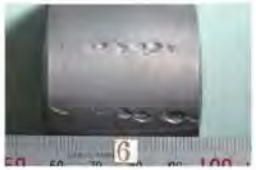


Example of reject result

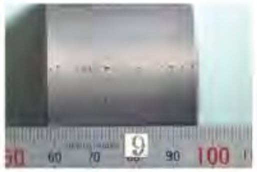
No.	Cause of judgment
2	Length of each independent broken part is less than 3mm, and added length of total cracks is more than 7mm
4	Total length of Incomplete penetration & slag inclusion on one side of weld line is more than 20mm
6	Total length of undercut on one side of weld line is more than 20mm
7	Length of independent broken part is more than 3mm
9	Total number of hole with 0.2mm dia. is less than 10
10	Broken part, IP,SI, gas hole are observed dominantly

Observation of bend test (Reject) ①





Observation of bend test (Reject) ②

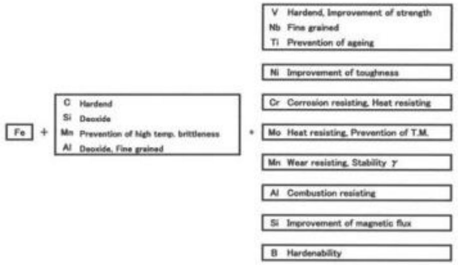


D-1-5. Welding Basics (Type of Welding Steel)

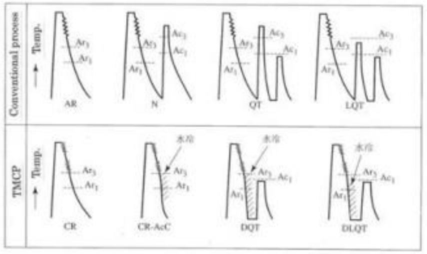
Various Kind of steels

Strength level	Type of steel	Chemical composition (wt.%) C	Si	Mn	Others element	Manufacturing Process	Mechanical properties Ts(Mpa)	vE0(J)
Mild steel	Ordinary type	0.18	0.13	0.83		AR	438	150
	ditto	0.14	0.41	1.44		N	540	196
HT490	High heat input resisting	0.1	0.24	1.19	V,Nb	CR-AcC	552	291(-40℃)
	Lammelar-tears resisting	0.14	0.43	1.42	Cu,Ni,V,Nb,Ca	N	540	235
	Weather resisting (High P)	0.1	0.46	0.42	P,Cu,Ni,Cr	AR	540	
	Weather resisting	0.14	0.27	1.13	Cu,Ni,Cr,V	AR	520	157
	Fire resisting	0.09	0.1	0.6	Cr,Mo	AR	541	352
HT590	Ordinary type	0.11	0.23	1.39	V,Nb,B	DQ-T	640	274
	Low yield ratio (for architecture)	0.12	0.27	1.44	Cu,Ni,Mo,V	DLQ-T	680	205
	Zinc-coated crack resisting	0.15	0.29	1.2	Nb,Ti	AR	610	250
HT780	Ordinary type	0.11	0.22	0.9	Cu,Ni,Cr,Mo,V,B	QT	820	198
	Cu precipetation type(*)	0.06	0.26	1.34	Cu,Ni,Cr,Mo,V	DQ-T	837	208(-40℃)
HT980	Ultra heavy thickness (Penstock)	0.11	0.22	0.9	Cu,Ni,Cr,Mo,V,Nb,B	DQ-T	1018	212
	Wear resisting	0.28	0.24	1.42	Cu,Cr,Mo,B	Q	1638	37

* Improvement of hydrogen induced crack susceptibility

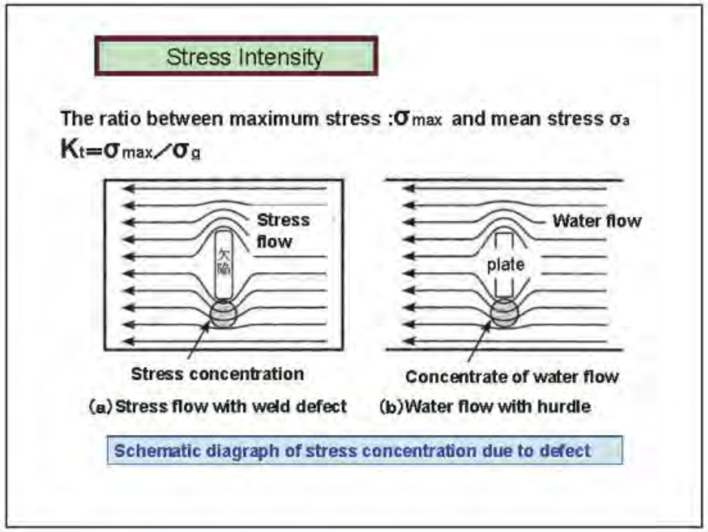


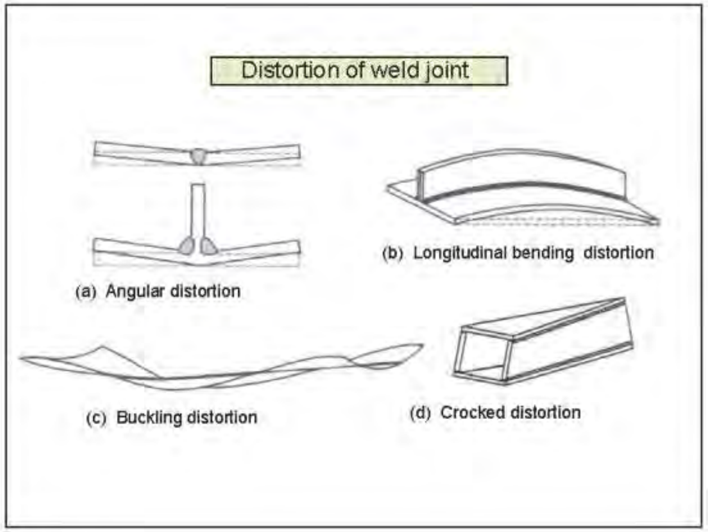
Effect of chemical elements respectively



Schematic of Heat cycle on steel making

D-1-6. Welding Basics (Steel Intensity and Distortion)





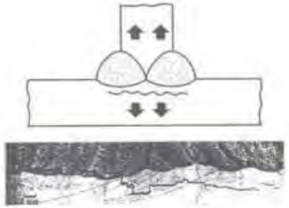
D-1-7. Welding Basics (Welding Imperfection)

Lamellar tear

Character of cracking;

1) To occur at the weld joint such as cross type or T-type joint, in which welding stress flows forward gauge direction

2) To peel off the inclusion which become depress by steel rolling



Anti-lamellar tear: Decreasing of inclusion (MnS)

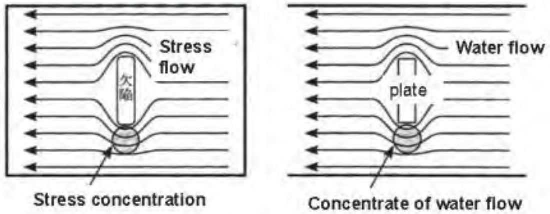
An Example of the occurrence galvanized cracking

Microstructure of galvanized cracking

Stress Intensity

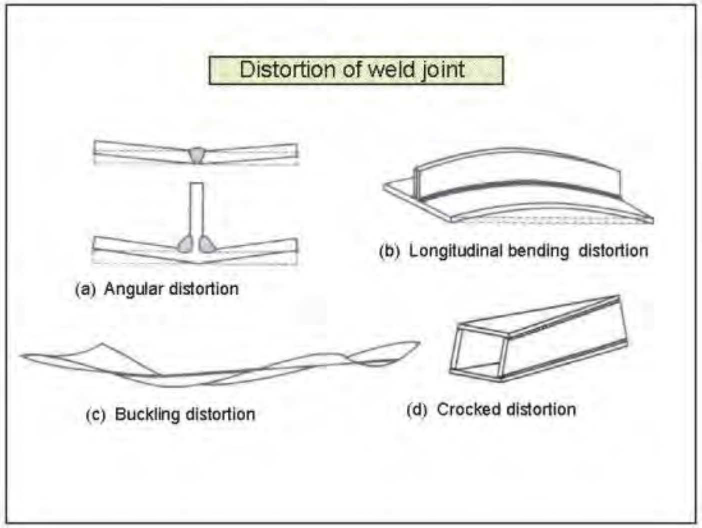
The ratio between maximum stress : σ_{max} and mean stress σ_a

$$K_t = \sigma_{max} / \sigma_a$$

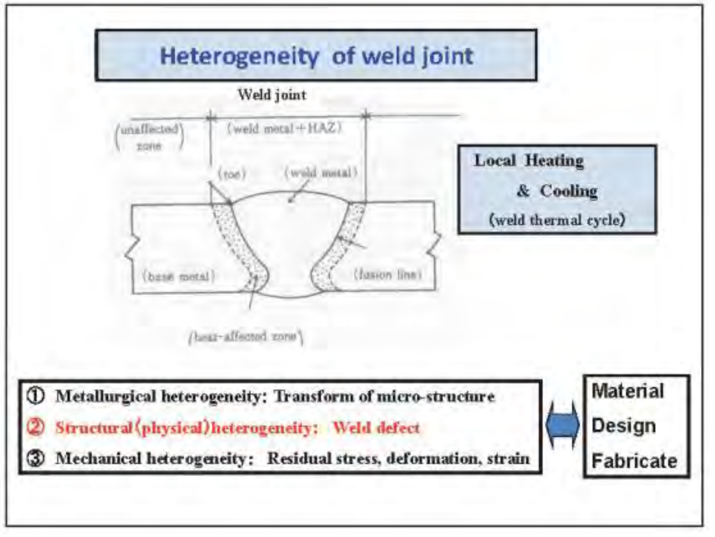


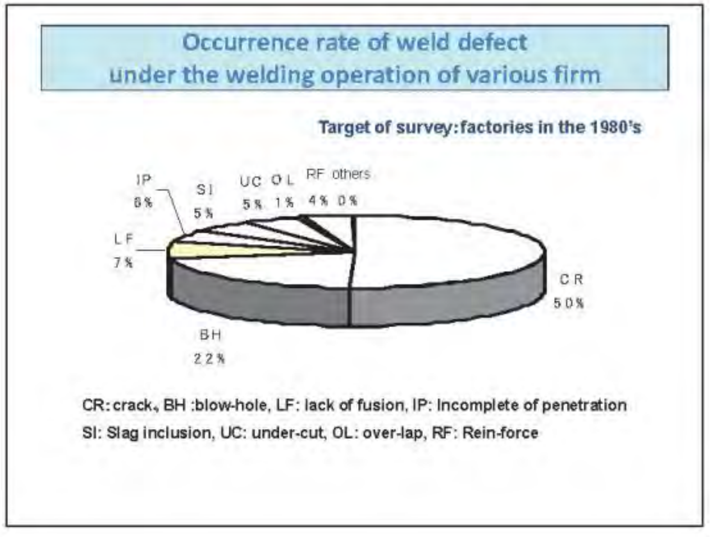
(a) Stress flow with weld defect (b) Water flow with hurdle

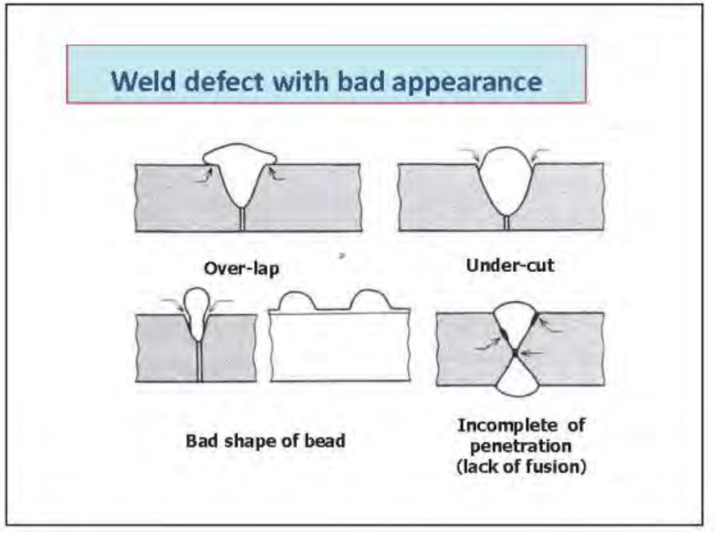
Schematic diagraph of stress concentration due to defect

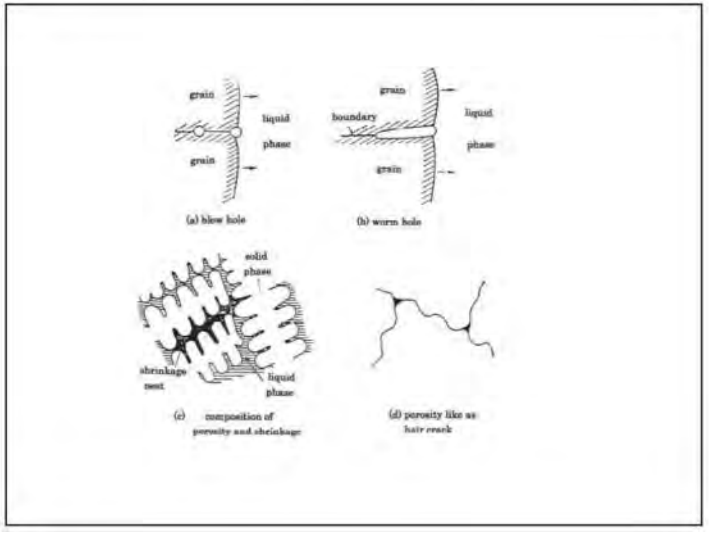

Distortion of weld joint
(a) Angular distortion
(b) Longitudinal bending distortion
(c) Buckling distortion
(d) Crocked distortion

D-1-8. Welding Basics (Welding Defect: Pores)









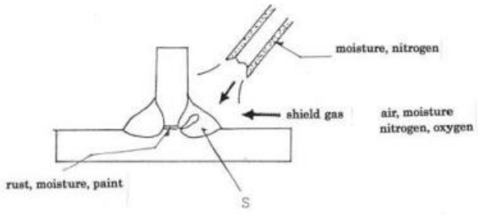
Porosity (Blow hole)

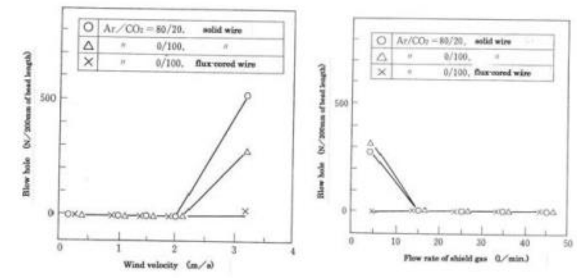
Caused :

① ejection of resolved gas depend on the difference of solubility
② chemical reaction in the molten pool (CO_2, H_2S etc.)
③ physically mix up shield gas

Measure :

① removal of moisture on the plate surface, oil, rust and paint
② storage control and/or drying treatment of consumable materials
③ stabilize for shield function, protect for wind
④ choice of optimum arc length and suitable arc condition





Deoxidized operation of CO_2 arc welding

① Decomposition of CO_2 gas in arc atmosphere

$$CO \rightarrow CO + O$$

② Chemical reaction of ferrous element with oxygen in molten pool

$$Fe + O \rightarrow FeO$$

③ De-oxidation by deoxidizing agents in filler wire and/or flux

$$FeO + Mn \rightarrow MnO + Fe$$

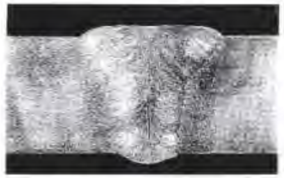
$$2FeO + Si \rightarrow SiO_2 + 2Fe$$

④ If any deoxidizers do not include, priority chemical reaction becomes as follow.

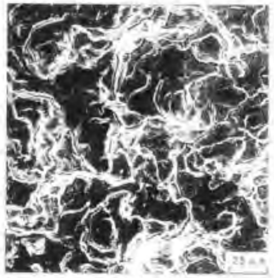
$$FeO + C \rightarrow Fe + CO$$

Consequently, carbon oxide (CO) accounts for blow hole.

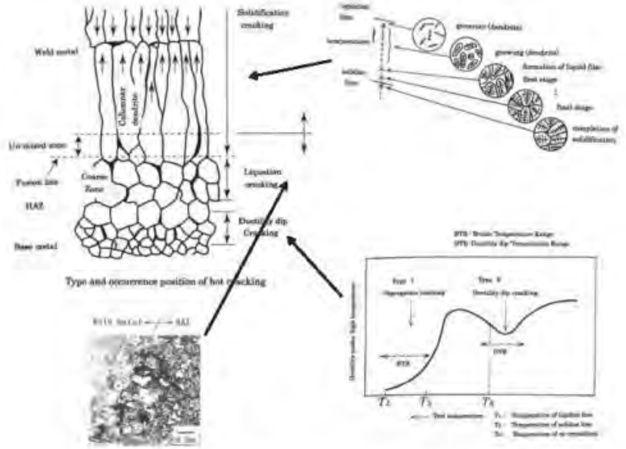
D-1-9. Welding Basics (Welding Defect: Cracks at High Temperatures)



Solidification cracking of sub-merged arc welding (thickness :25mm)

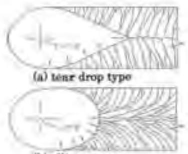


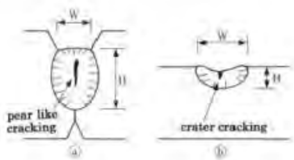
Observation of fracture surface for solidification cracking by scanning electron beam microscope



Prevention of hot cracking

Causes	Coutermeasures
Chemical composition of materials	Decreasing impurity elements (especially P: phosphorus, S: sSulfu) Decreasing Carbon, Nickel content and so on
Profile of weld bead	Keeping suitable profile of molten pool (from tear-drop type to ellipse type) (to select properly combination between heat input and welding speed) Keeping optimum bead shape factor (H/W; H: penetration, W: bead width)
contraction shift	Rejection excessive high restraint, (to select suitable joint design amd fabricated process

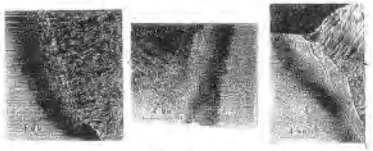




D-1-10. Welding Basics (Welding Defect: Cracks at Low Temperatures)

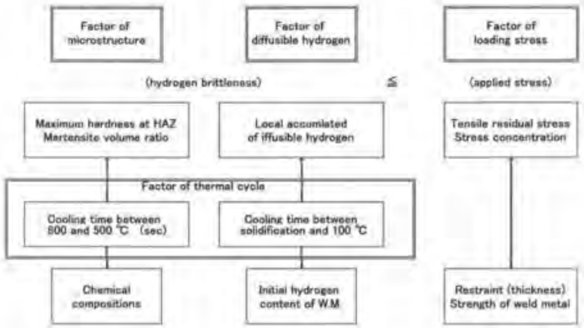
Prevention of cold cracking

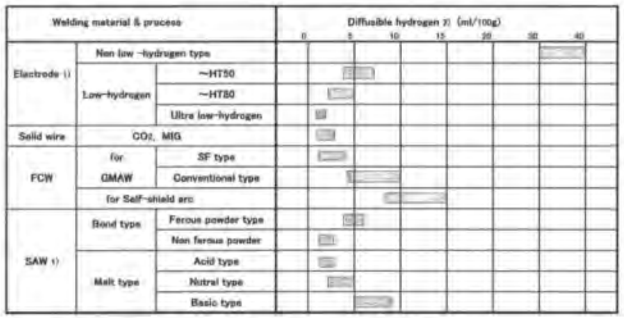
Causes	Countermeasures
Chemical composition	To control the hardened microstructure (1) low carbon agivalent (2) slow thermal cooling rate = preheating
Diffusible hydrogen	To control the accumulation of diffusible hydrogen at cracking site (1) low initial hydrogen content of weld metal (2) slow thermal cooling rate = preheating
Tensil strength	To control the restraint and stress concentration of weld joint (1) simple joint design (2) low strength of weld metal etc.



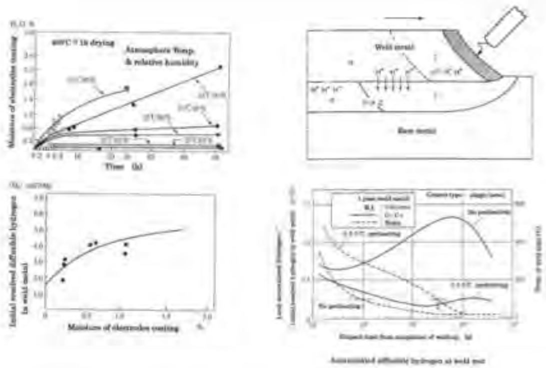
Root crack Under-bead cracking Toe cracking

Main type of cold cracking

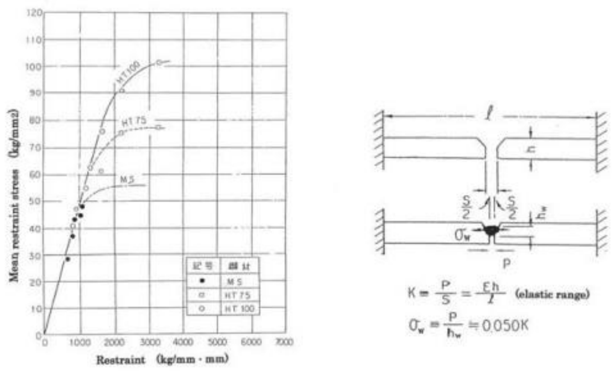


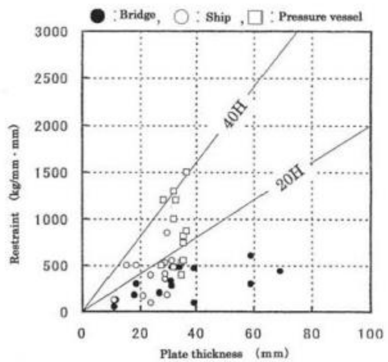


Note: 1) Re-dry at specified temperature. 2) by using gas-chromatograph method
cf. By glyceline method for non low-hydrogen type



Dryness of electrode **Preheating**


Mean restraint stress (kg/mm2)
Restraint (kg/mm · mm)
HT100
HT75
MS
記号
鋼材
MS
HT75
HT100
ℓ
h
S/2
S/2
h_w
σ_w
P
$K = \frac{P}{S} = \frac{Eh}{\ell}$ (elastic range)
$\sigma_w = \frac{P}{h_w} \fallingdotseq 0.050K$


● : Bridge, ○ : Ship, □ : Pressure vessel
Restraint (kg/mm · mm)
Plate thickness (mm)
40H
20H

D-1-11. Welding Basics (Welding Defect: Welability and Material Test)

History of welding process

by H.Kihara (SANPO Publish)

1802	Petrow	Research of Arc (R)
1845	Staite	License of arc weld for metal (B)
1867	Thomson	Electric resistance weld (U)
1891	Slavianoff	Arc welding with metal electrode (R)
1930	Robinoff, Paine, Quillen	License of Submerged Arc Welding (U)
1936		MIG welding with helium gas (U)
1943		Semi-automatic SAW (R)
	Behr	Ultrasonic welding process (U)
1948	Chudikow	Friction welding process (R)
	Steigerwald	Electron-beam(EB) welding process (G)
1953	Sekiguchi, Masumoto, Lyvatskii, van der Willingen	Practical use of CO2 GMAW (J,R,N)
1955		Practical use of cold pressure weld
1957	Stohr	Practical use of EB (F)
	Kazakov	Diffusion welding (R)
		Laser welding (U)
1960	Maiman	Stir friction welding (FSW) (B)

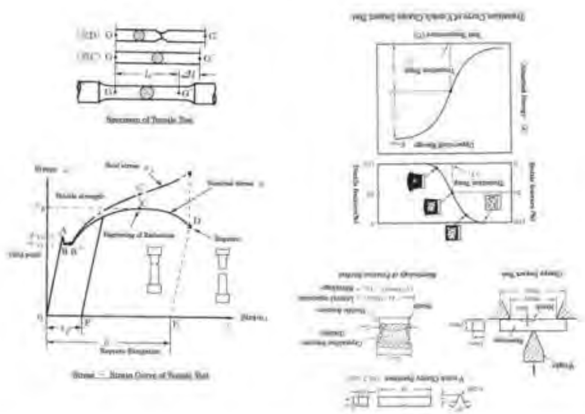
R:Russia(Soviet), B: Britain, U: USA, G:Gamany, J:Japan, N: Netherland, F:France

Weldability

Definition in a narrow sense: Suitability for fabrication
Satisfactory weld quality without defects, especially hydrogen induced cracks
Definition in a broad sense: Suitability for service performance
Good ductility and strength, satisfactory notch toughness in weldment
Resistance against fatigue crack growth and/or corrosion cracking

Test of Weld joint
- Destructive test
  - Mechanical test: Tensile test, Impact Test, Hardness test, Banding test, Fatigue test etc.
  - Physical test
  - Chemical test
  - Metallurgical test: Macrostructure test, Microstructure test by optical microscope
  - Brittle fracture test: Fractography (Study on fracture surface)
  - Weldability test: Hardenability test(Maximum hardness), Susceptibility for weld cracks
  - Others test
- Nondestructive test: (UT,PT,MT,RT etc.)

Classification of testing method of welded joint



D-1-12. Welding Basics (Weld Joint)

Significant performance required for work pieces and their weld joint

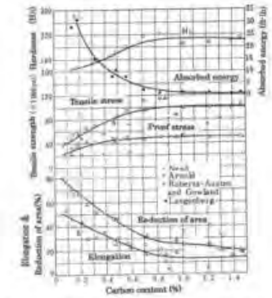
- Static strength
  - Tensile strength — σ B (N／mm2,　kgf／mm2)
  - Proof strength — σ y (N／mm2,　kgf／mm2)
- Dynamic strength
  - Absorbed energy — vE (J,　kg·m)
  - Transition Temp. — vTrs(K,　℃)

⇧

Microstructure of Metal
Grain size of Crystal

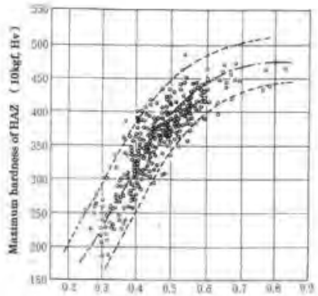
⇧

Chemical Composition of Steel
Weld Thermal Cycle



Relationship between mechanical properties and carbon content

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

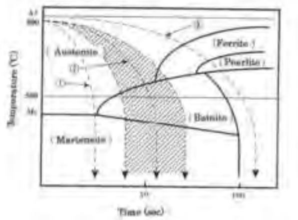


C_{eq} = C + 1/6Mn + 1/24Si + 1/40Ni + 1/5Cr + 1/4Mo + 1/14V (%)

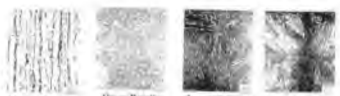
t 8/5 = 6 sec (standard welding condition: 170A x 24V x 15cm/min.)

Relationship between maximum hardness and carbon equivalent

① Arc strike
② Suitable condition of weld
③ Excessive heat input and/or excessive high temperature of plate in multi-pass welding



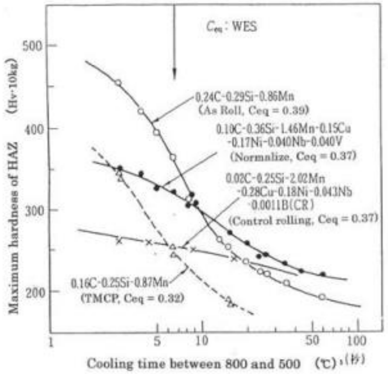
(2) t8/5 : Cooling time between 800 and 500 ℃



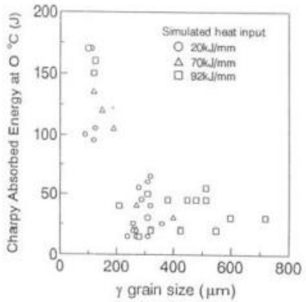
Slow cooling (long) ——— Rapid cooling (short)

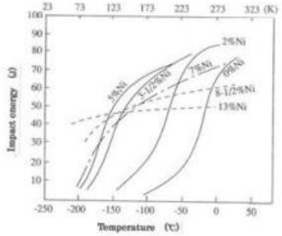
Softening ——— Hardening

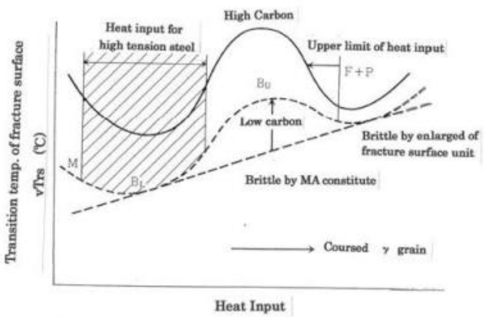
good toughness



Maximum hardness of HAZ for HT50 steel



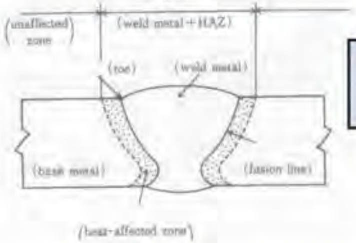




Toughness of HAZ influenced by variation of microstructures

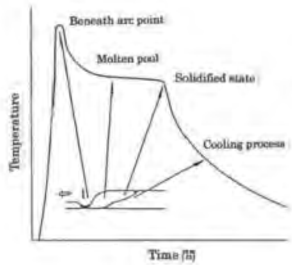
D-1-13. Welding Basics (Histogenesis)

Heterogeneity of weld joint

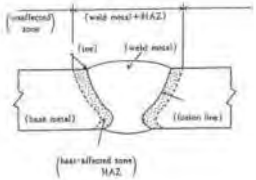


Local Heating & Cooling (weld thermal cycle)

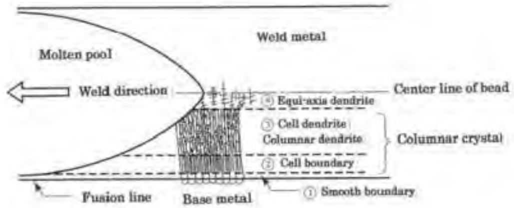
① Metallurgical heterogeneity: Transform of micro-structure ② Structural (physical) heterogeneity: Weld defect ③ Mechanical heterogeneity: Residual stress, deformation, strain	Material Design Fabricate



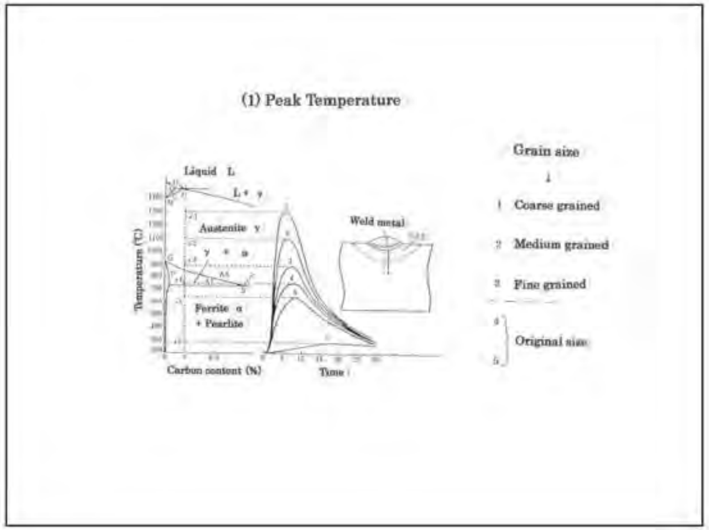
Example of thermal cycle

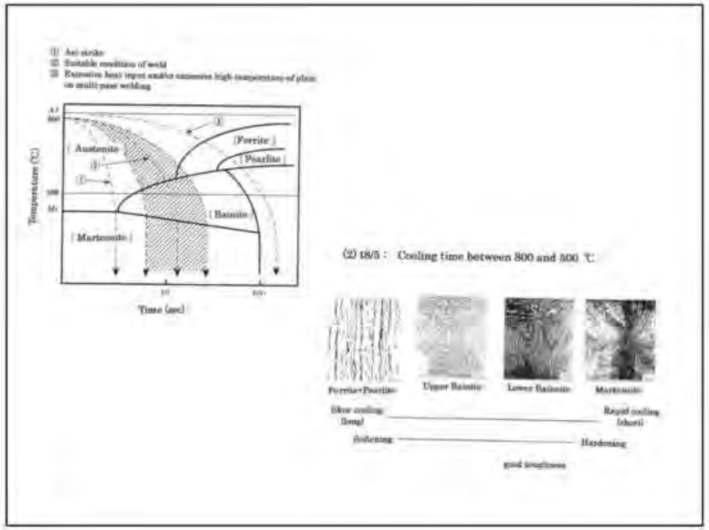


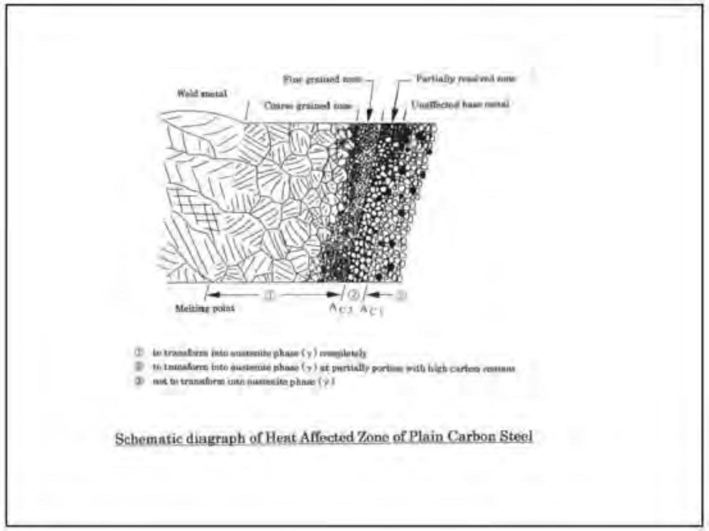
Cross section of weld joint



Solidification model of deposit metal


(1) Peak Temperature
Liquid L
L + γ
Austenite γ
γ + α
Ferrite α
+ Pearlite
Temperature (℃)
Carbon content (%)
Time
Weld metal
Grain size
↓
1 Coarse grained
2 Medium grained
3 Fine grained
4
5
Original size


[Austenite]
[Ferrite]
[Pearlite]
[Bainite]
[Martensite]
Temperature (℃)
Time (sec)
(2) t8/5 : Cooling time between 800 and 500 ℃
Slow cooling
(long)
Rapid cooling
(short)
Softening
Hardening


Weld metal
Coarse grained zone
Fine grained zone
Partially resolved zone
Unaffected base metal
Melting point
Schematic diagraph of Heat Affected Zone of Plain Carbon Steel

D-1-14. Evaluation of Welding Skill (PCFCT)

Evaluation of welding skill for Bead-on test

- Visual inspection for weld bead
  - Check points : Straightness, uniformity of bead shape, ripple, presence of defects

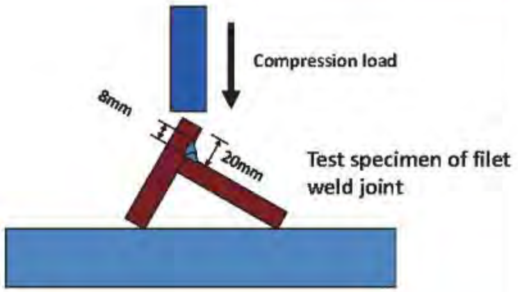
	Straight ness	Uniformity of bead shape	Undercut	Overlap
Basis	Curving more than bead width is not acceptable	Deviation more than half size of bead width is not acceptable	Undercut with sharp notch more than 20mm length is not acceptable	More than 2 times of bead width is not acceptable (angular at weld toe < 90°)
Score	100,90,80, 70,60,50,40	100,90,80,70,60, 50,40	100,90,80,70,60,50 ,40	100,90,80,70,60, 50,40
Remark	Trainee get mean score more than 70 , and then go up to next stage Each evaluation term ; less than score 40 is Disqualification: re training Score 80 : good, score 90; excellent			

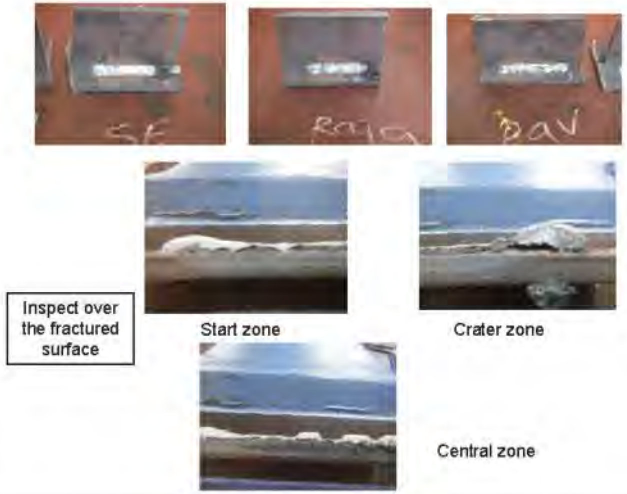
Practical training of Horizontal filet welding

Straightness of weld bead is not good

Soundness Test

Compact bending test for filet weld joint





Evaluation method for filet weld joint

Kind of imperfection	Acceptable size (ISO 5817 Level B)
cracks	Not acceptable
Gas pocket & dispersed porosity	The total sum of imperfection should be less than 1% of observed area and also the size of independent imperfection should be less than 3mm.
Gathered porosity	The total sum of imperfection should be less than 4% of observed area and also the size of independent imperfection should be less than 3mm.
Elongated pore & warm hole	The size (height & width) of imperfection should be less than 2mm.
Inclusion (steel)	The length of imperfection along welding direction should be less than 25mm.
Inclusion (other metal)	The size (height & width) of imperfection should be less than 2mm.
Lamination	Not acceptable
Lack of fusion	
Incomplete penetration	

D-1-15. Fundamental Knowledge of Welding Process

Fundamental knowledge of welding process

Nov. ‘2016

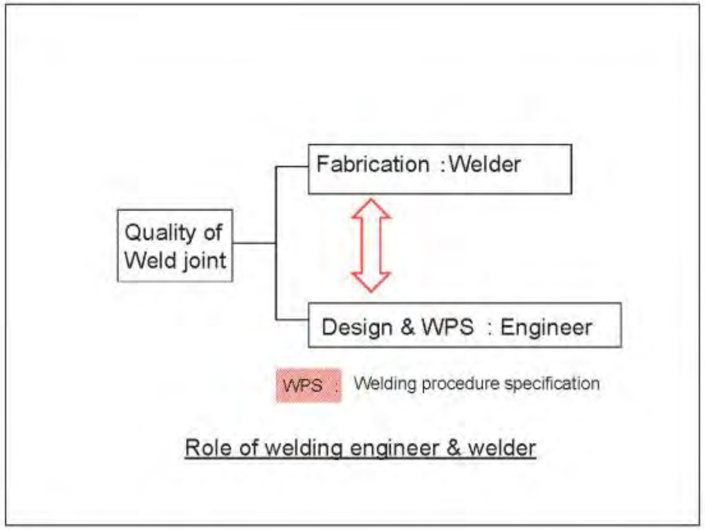
The Japan Welding Technology Center (JWTC)

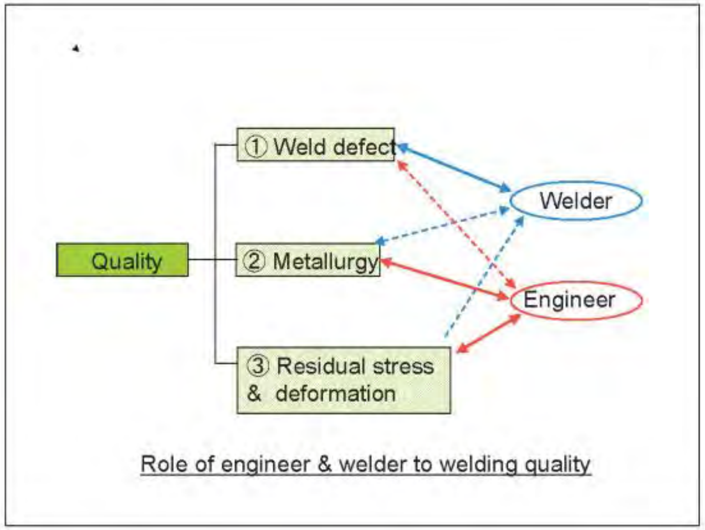
Old bridge (KACHIDOKI in Tokyo) constructed on 1940

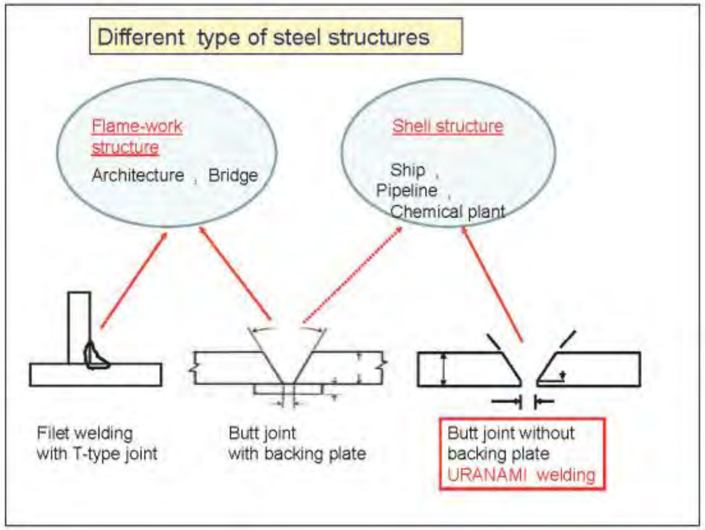
(Rivet joint)

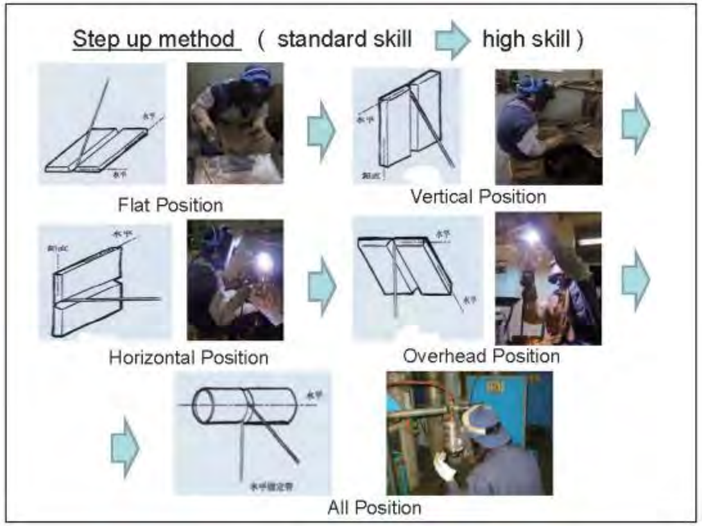
Suspension Bridge (AKASHI channel) : Total length 3911m, max. span 1991m, Tower height 298.3m, construction period 1986-1998


Manufacturing of Steel Products & Infrastructures
Key Technology
Arc Welding
Bridge
Architecture Building
Vessel
Chemical Plant
Gas Pipeline

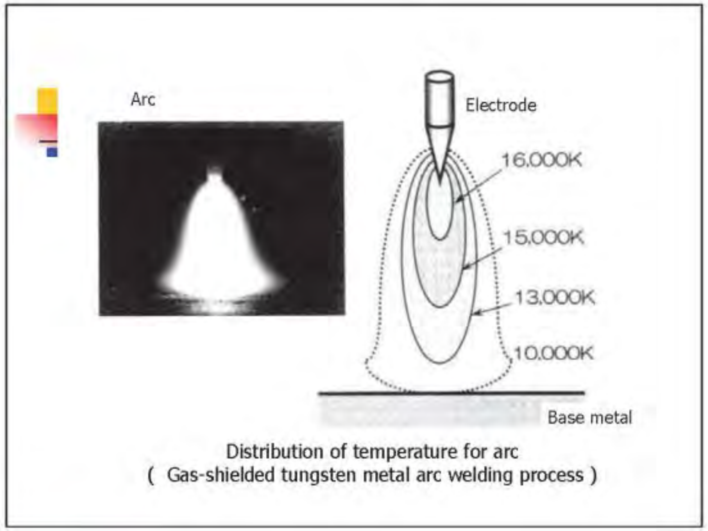

Quality of Weld joint
Fabrication : Welder
Design & WPS : Engineer
WPS : Welding procedure specification
Role of welding engineer & welder

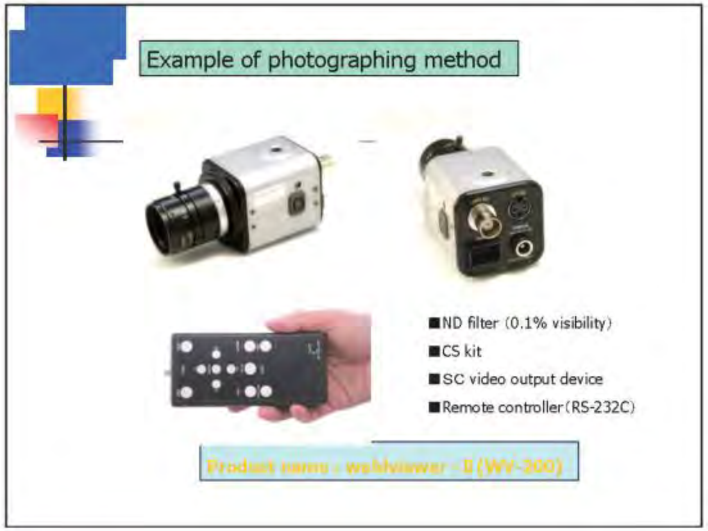

Quality
① Weld defect
② Metallurgy
③ Residual stress & deformation
Welder
Engineer
Role of engineer & welder to welding quality

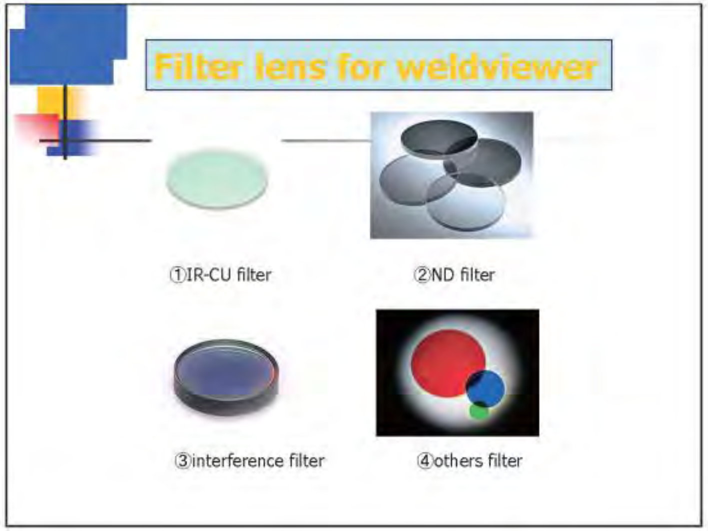

Different type of steel structures
Flame-work structure
Architecture , Bridge
Shell structure
Ship , Pipeline , Chemical plant
Filet welding with T-type joint
Butt joint with backing plate
Butt joint without backing plate
URANAMI welding

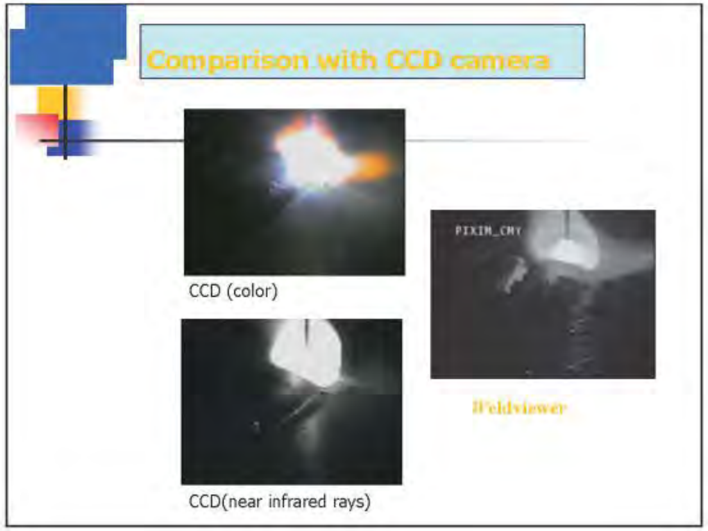

Step up method (standard skill high skill)
Flat Position
Vertical Position
Horizontal Position
Overhead Position
All Position

D-1-16. Photos of Arc Phenomena and Welding Process









Inspection of welding arc

ArcFilterGlobular.avi

Short-circuit transfer

Short-circuit transfer.avi

Globular transfer

Globular Transfer.avi

Spray transfer

Spray inclin.avi

Straightness weld arc

Stability of weld arc

Instability of weld arc

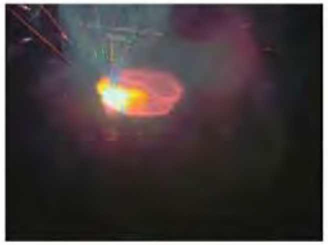
Photographing of arc at GMAW process
V-groove of flat position (first layer)

Trainer	beginner

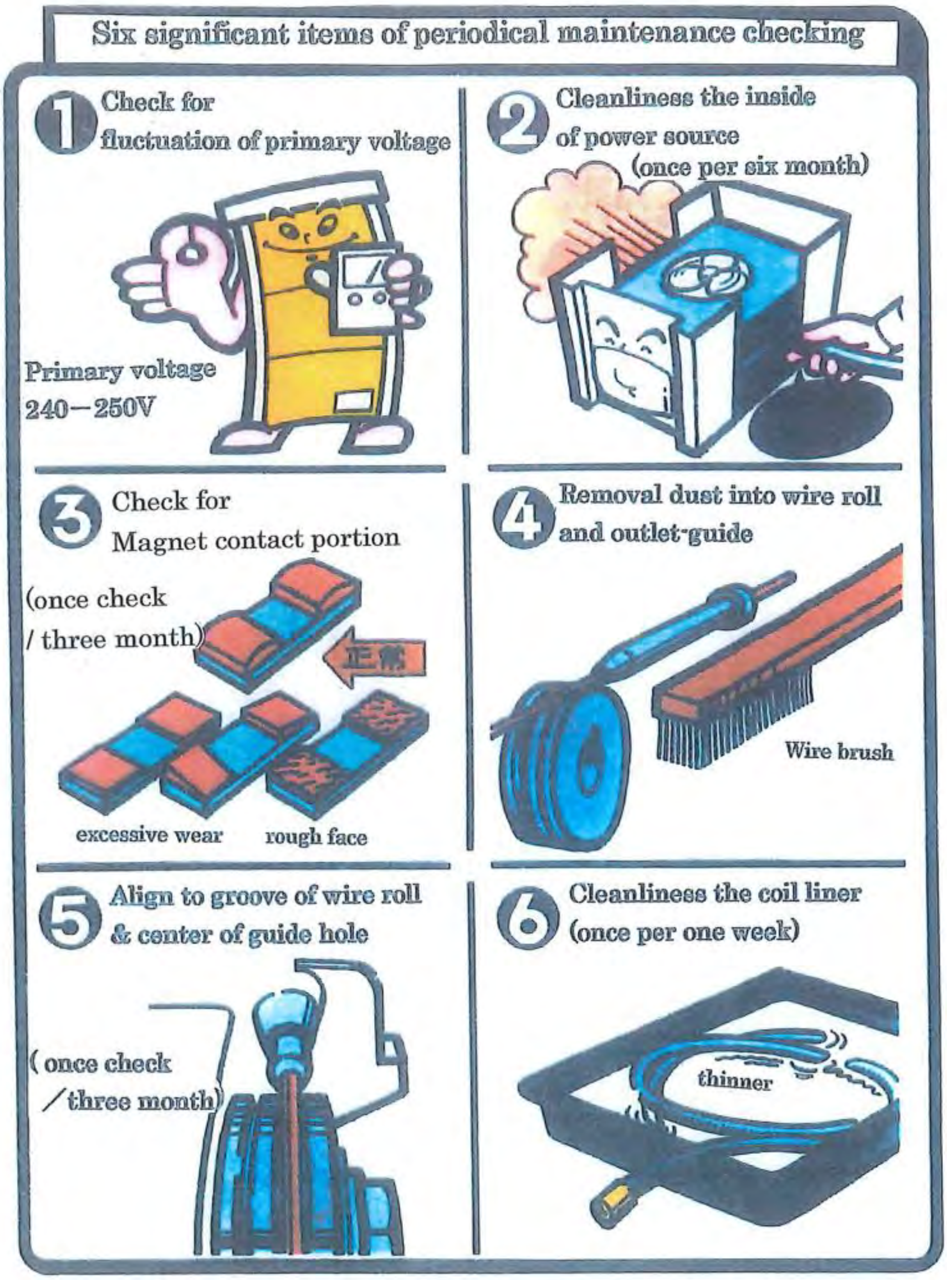
Video by Shimomura

Video by Fukami

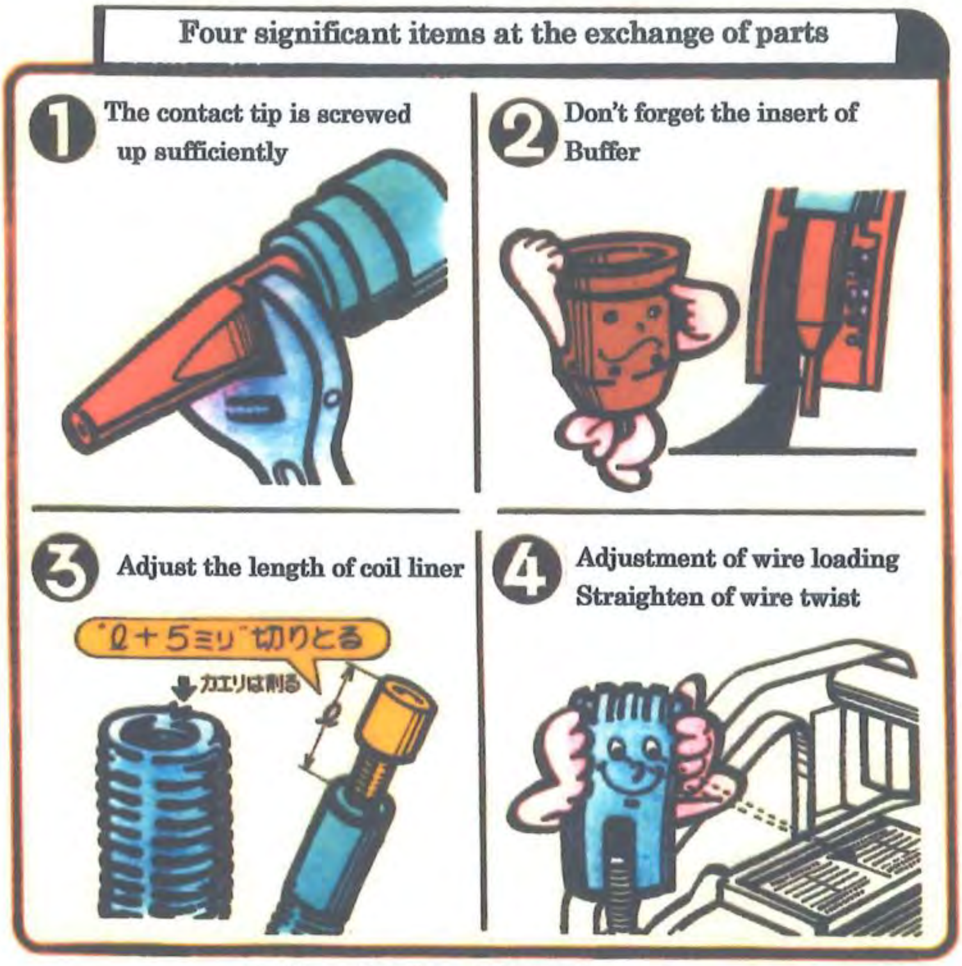
Photographing of arc at GMAW process
V-groove of flat position (third layer／final)

Trainer	Beginner
	
Video by Shimomura	Video by Fukami

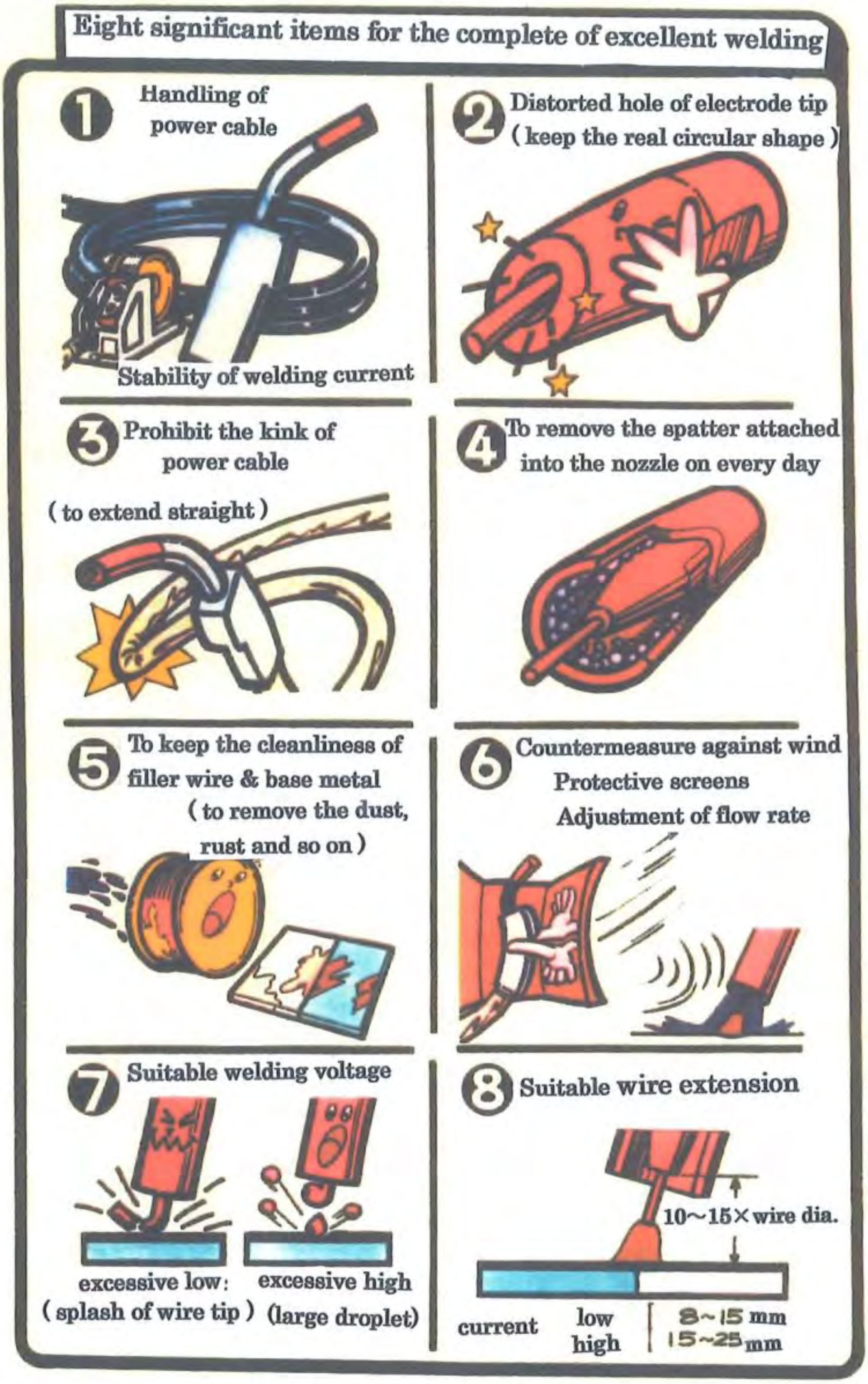
D-1-17. Reference Material 1 (Arc Welding)



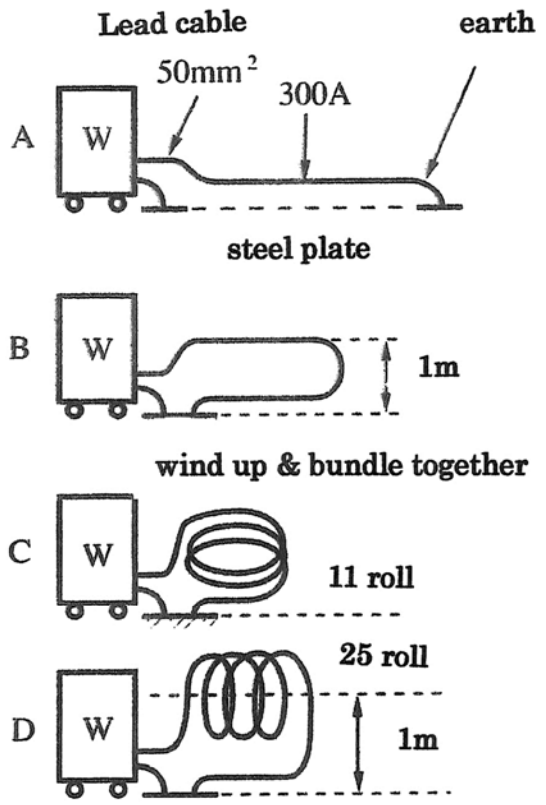
＊ Quotation from DAIHEN' s catalog
DAIHEN is one of famous Japanese welding company



* Quotation from DAIHEN' s catalog
DAIHEN is one of famous Japanese welding company



* Quotation from DAIHEN' s catalog
DAIHEN is one of famous Japanese welding company

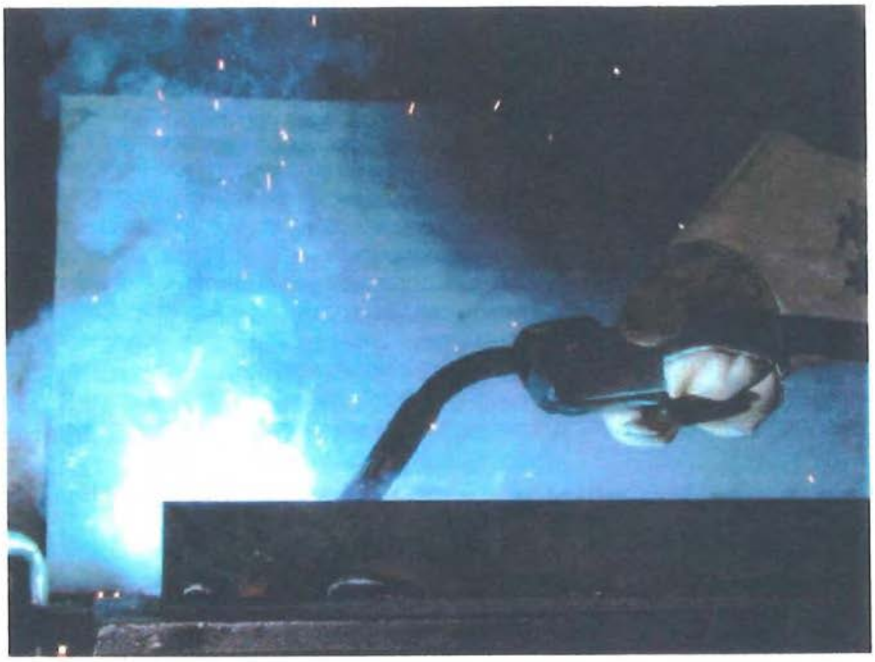


Drop of voltage (V)	
A	8～9
B	3～4
C	21～22
D	13～14

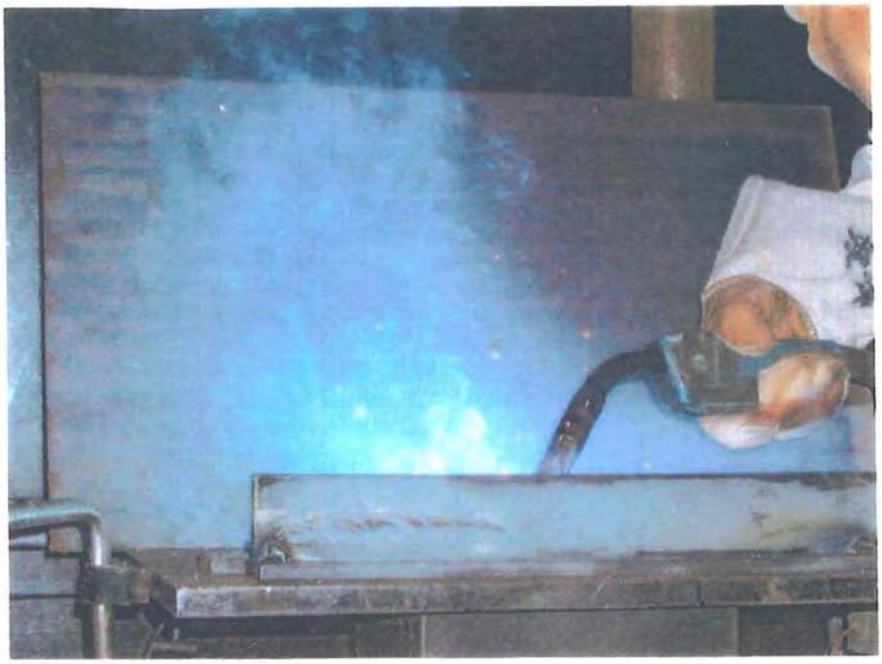
total length of lead : 25m

Condition of secondary lead & drop of voltage

Solid wire (300A, 33V)



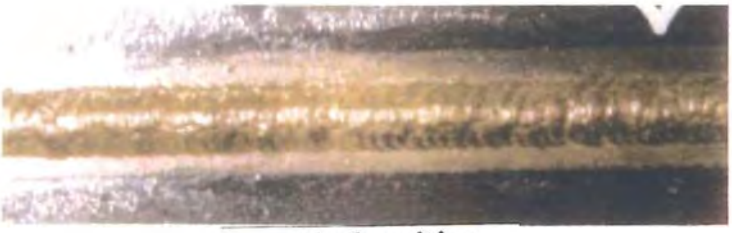
Flux-cored wire (300A,33V)



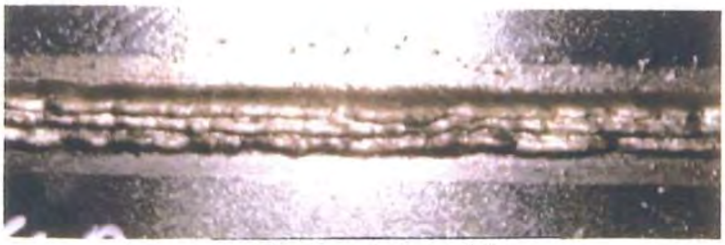
(100%CO2)

Appearance of GMAW weld-bead (100%CO_2)

flat position



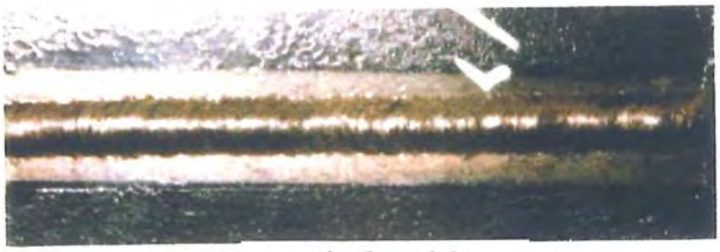
vertical position

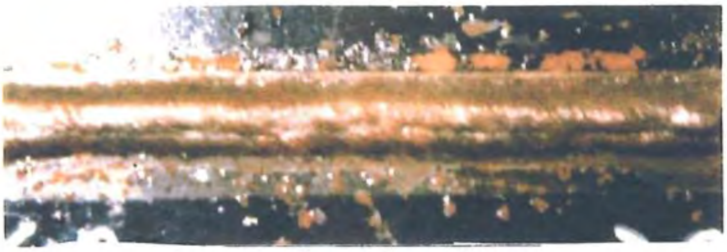


horizontal position

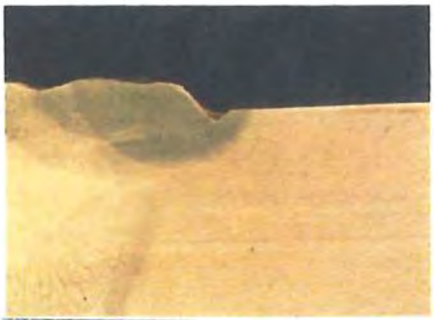
overhead position


flat position

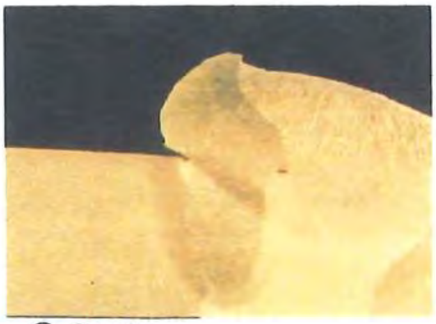

vertical position


horizontal position

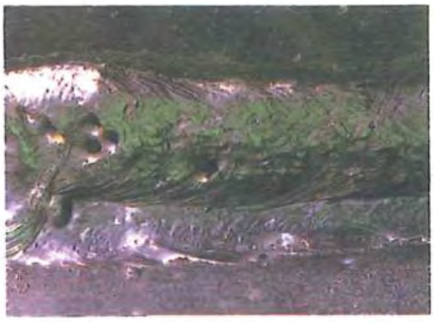

overhead position



① Undercut

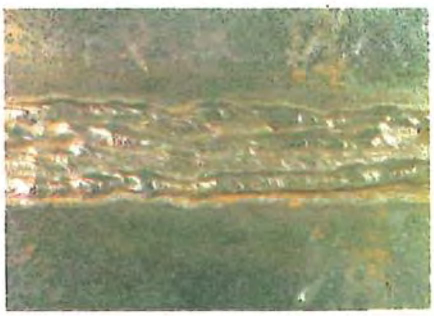


② Overlap



③ Pit

④ Crater



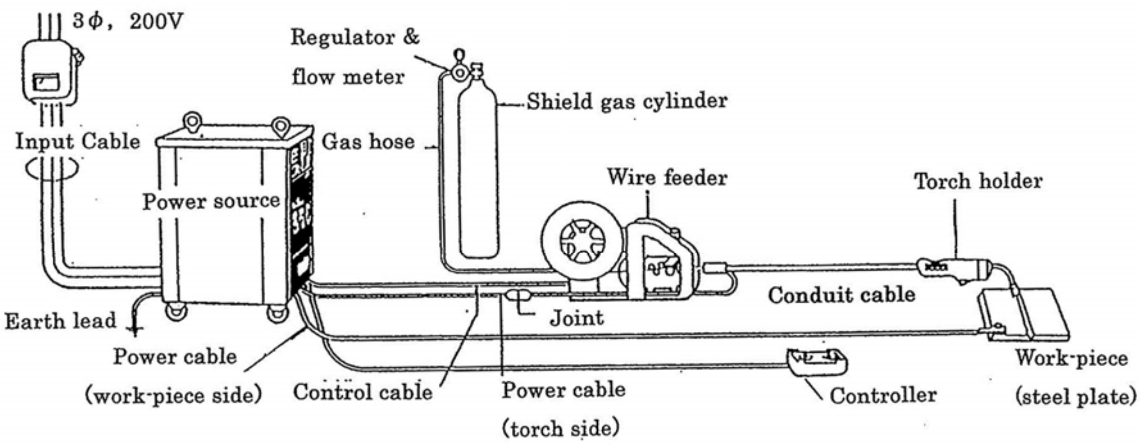
⑤ Incomplete of weld bead (relief)

⑥ Incomplete of weld bead (width)

D-1-18. Reference Material 2 (Arc Welding)

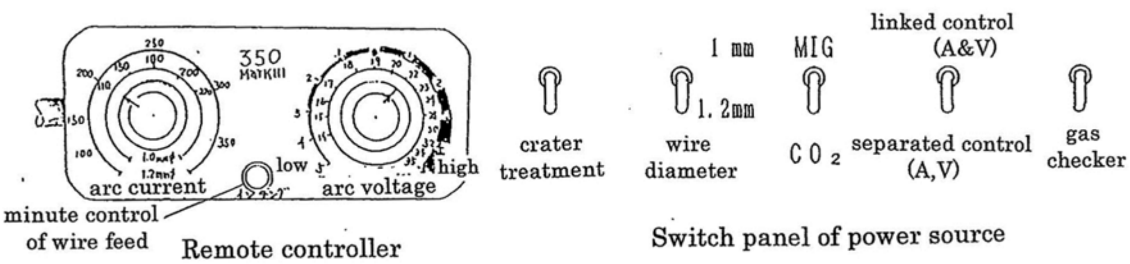
Semi-automatic welding process of CO2 gas shielded arc

1. Scope
   (1) Welding machine : Power source with direct current (DC), Rated current / max.350A
   (2) Steel : Mild steel(Plain carbon steel), thickness / 9mm
   (3) Filer wire : JISZ3312-YGW12(Dia. 1.2mm), to refer Appendix-1
   (4) Practical training menu: (a) Flat position, Bead-on plate
   (b) Flat position, V shape groove
   cf. Vertical position and/or horizontal position (option)
2. Basic composition of welding equipment
   General speaking, semi-automatic welding process of CO2 gas shielded arc and/or MAG arc is characterized by using a DC power source with constant potential characteristic, and also by using a wire feeder with constant velocity.



Equipments for semi-automatic welding process of CO2 gas shielded arc

3. Adjustment for arc current & voltage
   Firstly, to choose the separated control switch on the panel of power source, and then to adjust suitable arc current & voltage by using a remote controller.
   Where, wire diameter switch should be set 1.2 mm side and crater treatment switch should be put on.



(1) Adjustable method of arc voltage

$E = I \times 0.04 + 15.5 \pm 1.5$ (V) …… less than 230 A　　I : arc current

$E = I \times 0.06 + 13 \pm 1.5$ (V) …… more than 230 A　　E : arc voltage

- If you found that welding filer wire extend into molten pool, you should change to a high voltage condition due to operate the adjustable dial of remote controller.
- If you found that the droplet of wire tip transfer into molten pool like that a falling of raindrop, you should change to a low voltage condition due to operate the adjustable dial of remote controller. But, you must keep the value calculated depend on the above described equations.

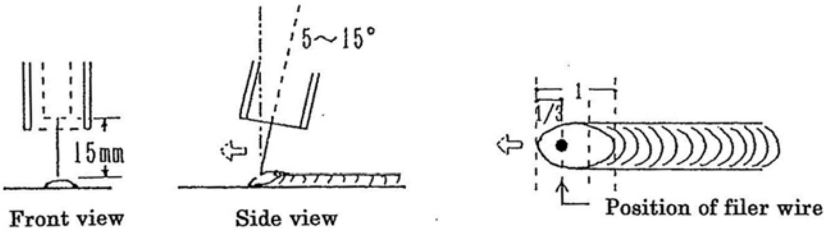
(2) Arc generate

- Firstly, to cut the tip of filer wire and to adjust that the length of the wire extension becomes 15mm. Secondly, to put on the power on switch of remote controller, the tip of filer wire touch the surface of work piece and then the arc generates.
- During weld, you should keep the arc length and/or wire extension, namely don't move the torch position toward the upper or lower direction and also operate the forward welding method. In this state, the angle of torch has to set in the range between 5 and 15 degree. (As shown bellow figure)

4. Practical training menu (1): Bead on plate with flat position

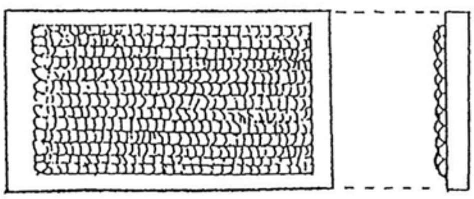
4-1 String bead

<u>Welding conditions</u>: Arc current/180A-200A, arc voltage/ 22V–23V, wire extension/ 15mm welding speed/ 25 – 30 m/min., flow rate of CO_2 gas/ 20 ℓ /min.



- You should operate the torch as if the tip of wire points toward the position where is one third of molten pool length from fused edge. And also you should control the welding speed like that the width of bead becomes approximately 10 – 12mm.
- When the welding speed exceeds the suitable range, the width of bead becomes excessively narrow and also becomes irregular.

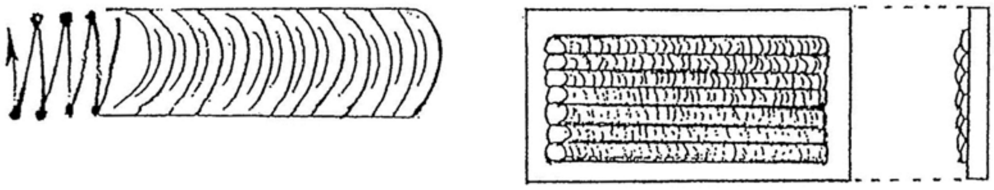
- On the other hand, when the welding speed falls bellow the suitable range, the overlap defect is generated due to the preceding of fused metal compare to arc position.



Training points of bead-on plate with string bead

4-2 Weaving bead

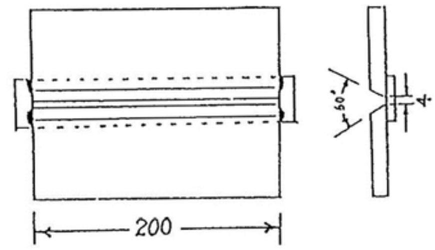
- Welding conditions are same as those of string bead. You should operate that the torch moves reciprocally 3-4 mm width perpendicular to a weld pass direction and stop for a 0.7 seconds at both sides. In this state, weld bead width is expected approximately 16-18 mm.
- You must notice the torch angle. If you tilt the torch excessively, the wire extension would become larger. As a result, the weld penetration become shallow due to the drop of arc current and the preceding of fused metal.



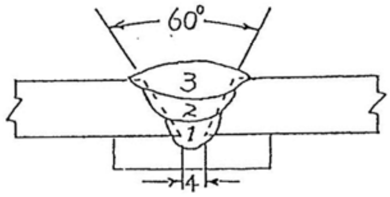
Training points of bead-on plate with weaving bead

5. Practical training menu (2): V shape groove with flat position
   (JIS-Z-3841 SA-2f refer to Appendix-2) Thickness of work piece: 9mm

Schematic diagram of weld specimen and welding pass sequence are shown as follow.
(Size and Shape)



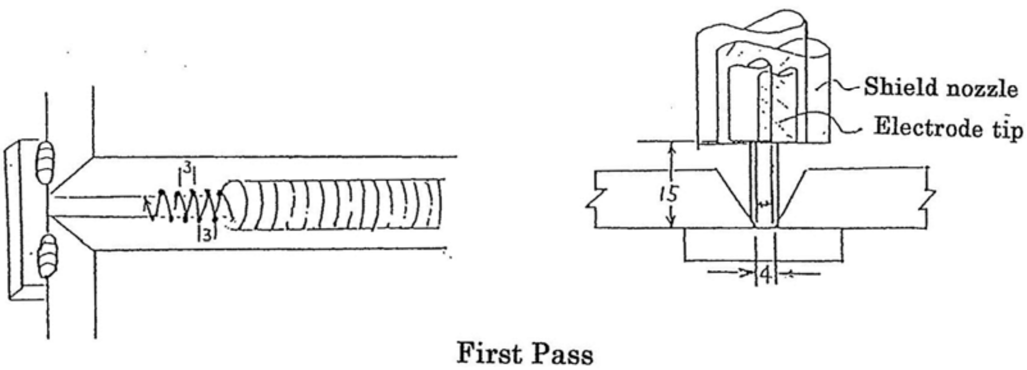
Size and shape of test specimen



Pass sequence

(1) Attention points of welding on first pass
Arc current / 200-220 A, arc voltage / 22-23 V, wire extension / 15 mm

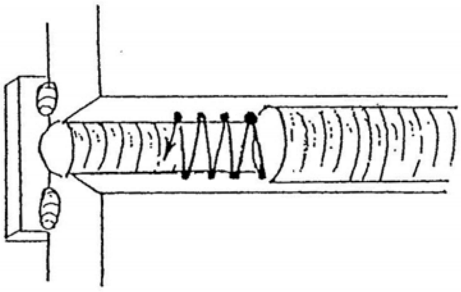
Position of arc point aims at the both corner of the weld root gap as shown the bellow figure. And also, you should keep the proper welding speed so that the fused metal could not flow over forward the arc position.

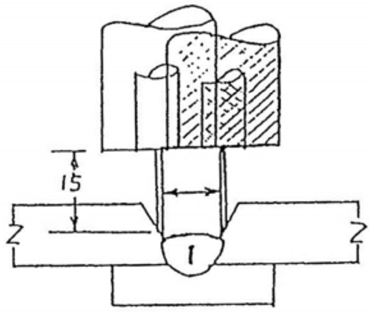


First Pass

(2) Attention points of welding on second pass

- Welding conditions are same as those of first pass. Position of arc point aims at the outside 1.2mm(filer wire diameter) off the both toe of first pass bead. Where, you should always stop briefly the torch at both corners in order to secure the complete penetration without the occurrence of any weld defects.
- If the stop duration overtimes excessively, the surface edges of weld groove would be fused. Consequently, it is difficult for you to weld the final pass on the proper position in order to lose trace of groove edges. The final weld pass becomes winding. Therefore, you should control the toe positions of second weld pass around 1.0-1.5mm beneath the top surface of work piece.
- On the other hand, If the stop duration is too short, the profile of pass bead would become convexity. Consequently, it is likely to occur the incomplete penetration, the lack of fusion and the slag inclusion.

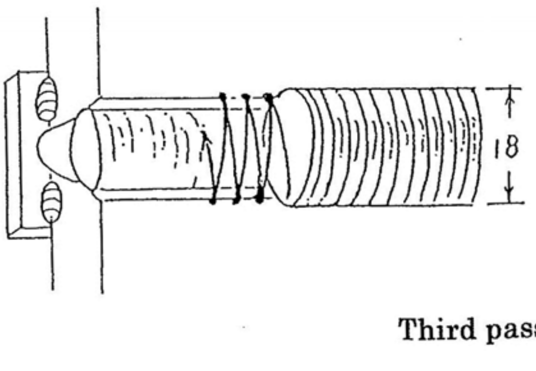


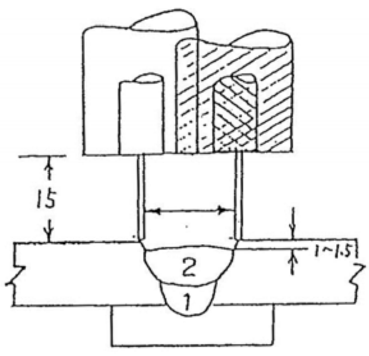


Second pass

(3) Attention points of welding on third pass

- The third pass is final pass. In this state, the temperature of work piece becomes considerably higher. Therefore, from the point of view that the appearance of bead surface is suitable, it is necessary to reduce the arc current slightly. That is to say, final weld pass is conducted under the condition in which arc current is 180A and arc voltage is 21-22V.
- The weaving process of final pass is the same as that of second pass. As the suitable bead profile of final pass, it is recommend that the bead width becomes approximately 17-18mm and the height of reinforcement becomes around 1-2mm.





Third pass

D-1-19. Resistance Welding Processes and Equipment

1

Welding processes and equipment

Resistance welding

The Japan Welding Technology Center

Kazuyoshi Hasegawa

The Japan Welding Technology Center
2016/10

2

Classification of Resistsnce Welding Processes

- RESISTANCE WELDING
  - LAP WELDING
    - SPOT WELDING
    - PROJECTION WELDING
    - SEAM WELDING
  - BUTT WELDING
    - UPSET WELDING
    - INDUCTION WELDING
    - FLASH WELDING
    - BUTT PROJECTION WELDING
    - BUTT SEAM WELDING
    - RESISTANCE BRAZING
    - INDUCTION BRAZING

The Japan Welding Technology Center
2016/10

3

Applications of Resistance Welding

Car, Motorcycle, Bicycle, Railroad carriage,
Airplane, Electrical appliance,
Architecture and building material

Automotive industry

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2016/10

4

Applications of Resistance Welding

Railway vehicle

can

The Japan Welding Technology Center
2016/10

Applications of Resistance Welding

5

fence

grating

Applications of Resistance Welding

6

gas turbine

Types of Resistance welds

7

UPSET WELD ex. Band Saw

Types of Resistance welds

8

FLASH WELD

Rail

Wheel for Track

Types of Resistance welds

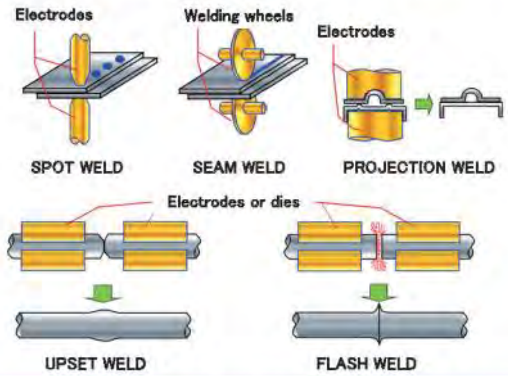
9

High nickel alloy Ni40%, Fe

pure titanium

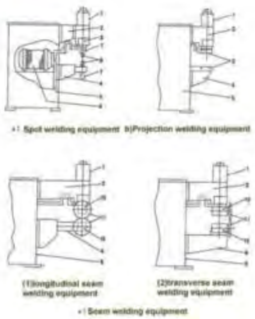
Various kind of Resistance welds

10



Construction of Spot, Projection and Seam Welding Equipment

11



Construction of Resistance Butt Welding Equipment

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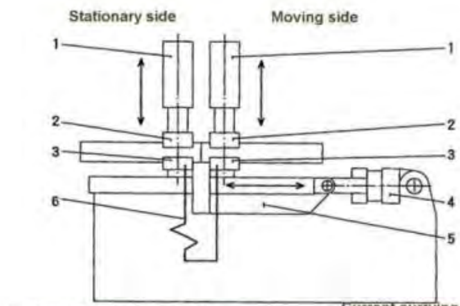
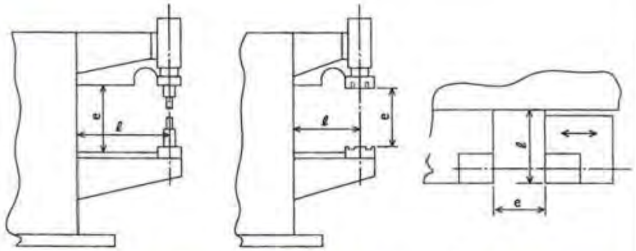


1 : Clamping device　2 : Clamping die　3 : Current currying clamping die
4 : Slide drive　5 : Slide　6 : Transformer

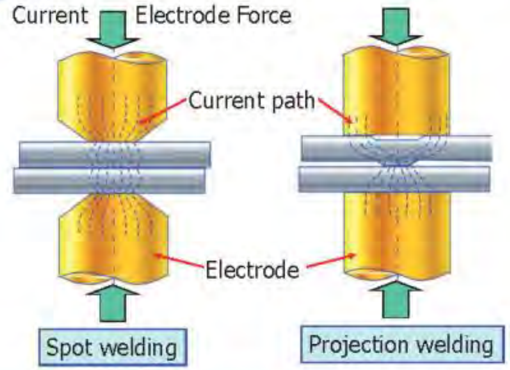
Main Dimensions



(a) Spot welding equipment (b) Projection welding equipment (c) Butt welding equipment(top view)

ℓ: throat depth e: throat gap clamping distance between the platens die distance

Principles of resistance spot welding method



Joule's Law

Joule's Law

$H = VIt = RI^2t$

Key

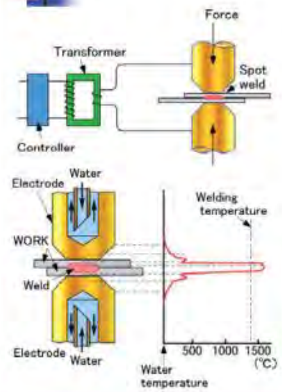
- Heat H(J)
- Voltage V(V)
- Current I(A)
- Time t(sec)
- Resistance R(Ω)

$Q = 0.24RI^2t$

Key

- Calorific value Q(Calorie)

Heat generation in spot welding and important parameters



Most important parameters in spot welding

1. **Welding current (I)**
2. **Welding time (t)**
3. **Electrode force**

A-90

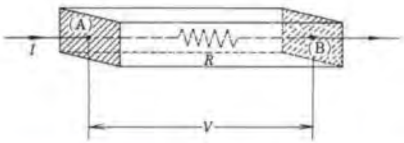
Ohm's Law

Ohm's Law

$$V=RI$$

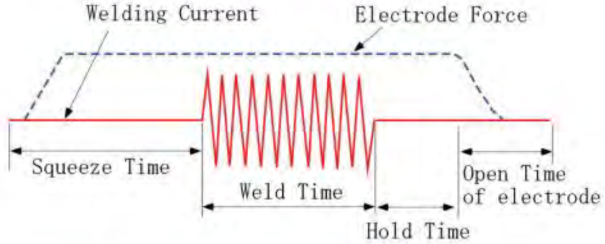
Key

- Voltage V(V)
- Current I(A)
- Resistance R(Ω)



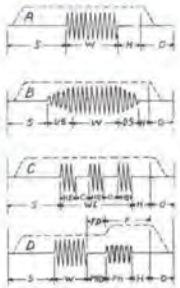
Current pattern −1

1. Normal current pattern (Single-impulse)



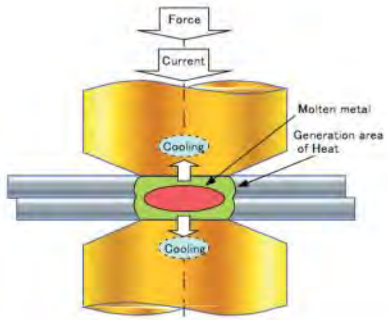
Current pattern −2

2. current pattern (Multipul-impulse)

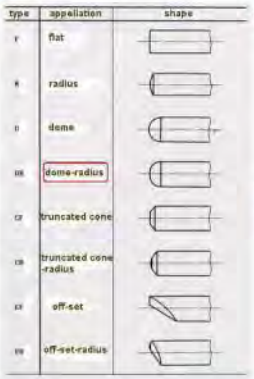


The Spot and Projection Weld Cycle, All Made with Automatic Repeating Electronic Timers
A—Single-Impulse Weld
B—Single-Impulse Weld with Up Slope and Down Slope Heat Control
C—Multiple-Impulse, or Pulsation Weld
D—Single-Impulse Weld with Forge and Post Heat Control

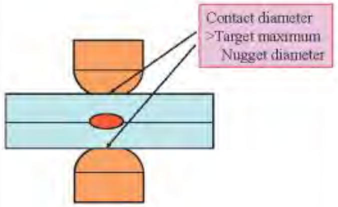
Heat balance at welded zone



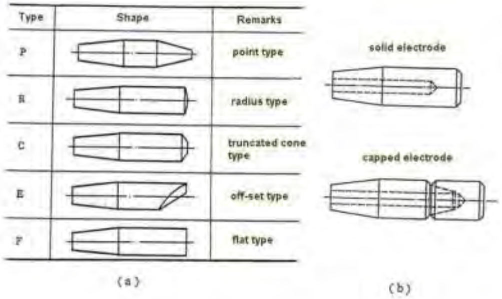
Type of Electrode geometry for spot welding



JIS



Electrode for spot welding



Recommended welding condition for mild steel sheet (WES)

Sheet thickness	CF-type electrode		A class			B class			C class		
mm	d mm	D mm	Electrode force kgf [N]	Welding time cycles	Welding current A	Electrode force kgf [N]	Welding time cycles	Welding current A	Electrode force kgf [N]	Welding time cycles	Welding current A
0.4	3.2	13	120 [1180]	5	5800	75 [736]	9	4500	40 [392]	20	3550
0.5	3.6	13	135 [1320]	6	6300	90 [883]	11	5000	45 [441]	22	4000
0.6	4.0	13	160 [1570]	7	7100	100 [981]	13	5600	56 [549]	25	4500
0.8	4.5	13	200 [1960]	8	8000	120 [1180]	16	6300	71 [696]	28	5000
1.0	5.0	13	250 [2450]	10	9000	150 [1470]	20	7100	90 [883]	32	5600
1.2	5.6	13	315 [3080]	12	10000	190 [1860]	25	8000	112 [1100]	40	6300
1.4	6.0	13	355 [3480]	14	10600	212 [2080]	28	8500	125 [1230]	45	6700
1.6	6.3	13	400 [3920]	16	11200	236 [2310]	32	9000	140 [1370]	50	7100
1.8	6.7	16	450 [4410]	18	11800	265 [2600]	36	9500	160 [1570]	56	7500
2.0	7.1	16	500 [4900]	20	12500	300 [2940]	40	10000	180 [1770]	63	8000
2.3	7.5	16	560 [5490]	23	13200	335 [3290]	45	10600	200 [1960]	71	8500
2.5	8.0	16	630 [6180]	25	14000	375 [3680]	50	11200	224 [2200]	80	9000
2.8	8.5	20	710 [6960]	28	15000	425 [4170]	56	11800	250 [2450]	90	9500
3.2	9.0	20	800 [7850]	32	16000	475 [4660]	63	12500	280 [2750]	100	10000

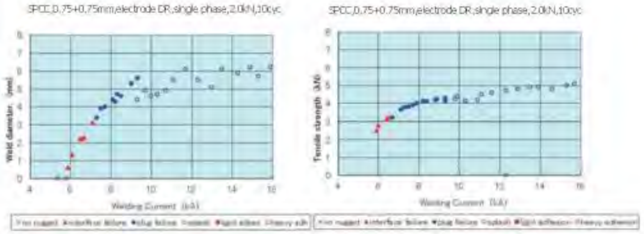
WES 7301-1986

Single phase alternate current, 60Hz

1-phase or 3-phase alternate current

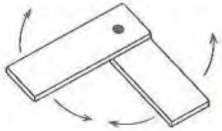
the growth of the nugget(SPCC)

SPCC 0.75+0.75mm DR single phase
2.0kN 10cycles



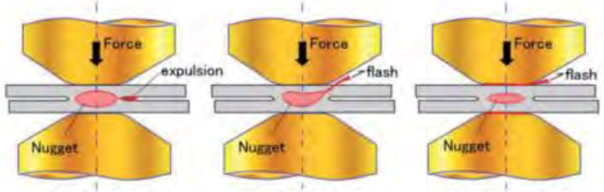
When the splash occurs, the nugget diameter is reduced.

Torsion test (JIS Z 3144)



Torsion test jig

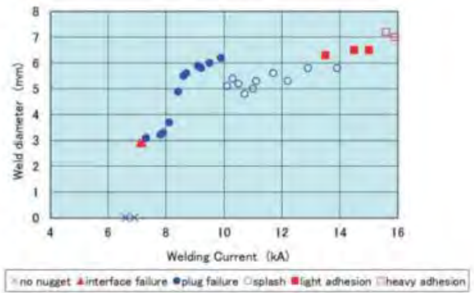
Expulsion on Spot welding



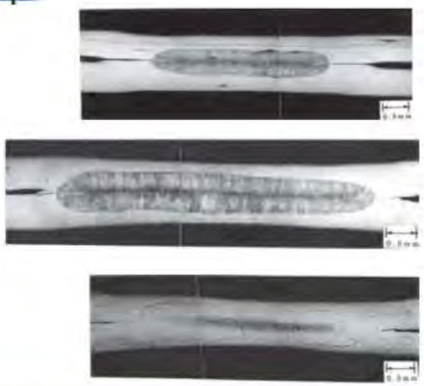
(a) Expusion (b) Surface flash (c) Coating flash

the growth of the nugget(Galvanneal steel)

Galvanneal steel45/45,0.7+0.7mm, 2.5kN,10cycles,DR electrode,Cu-Cr



The growth of the nugget



Galvanneal Steel
45/45 0.7+0.7mm
10cycles, 2.5kN
7800A

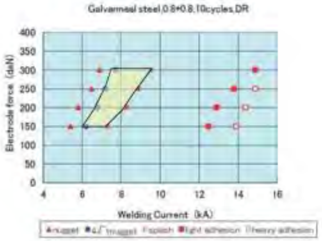
10000A
No Splash

10600A
Splash(Ring Pattern)

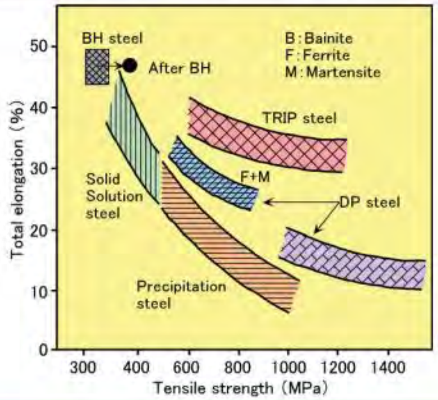
Weldability lobe of the Galvanneal Steel

Galvanneal steel45/45 0.8+0.8mm

Electrode DR Cu-Cr single phase Direct welding



Strength-elongation balance of steel sheet



Properties of HSS sheets compared with mild steel sheets from the viewpoint of spot weldability

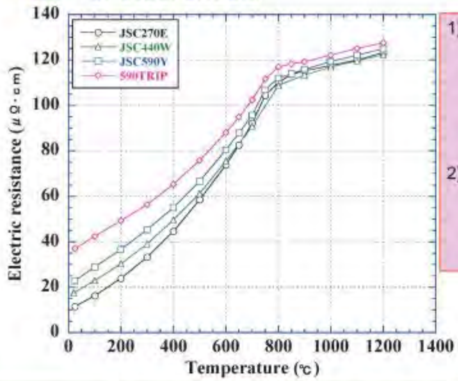
a) Welding current ranges of HSS sheets exist lower current side because electric resistance of HSS sheets are higher than that of mild steel sheet.

b) Not good quality welding (Nugget diameter is very small or nugget cannot be formed) is easily occurred when electrode force is low. This is because gap exist between sheets.

c) Microstructure at welded zone becomes to be martensite easily and Vickers hardness becomes to increase with increase of carbon equivalent.

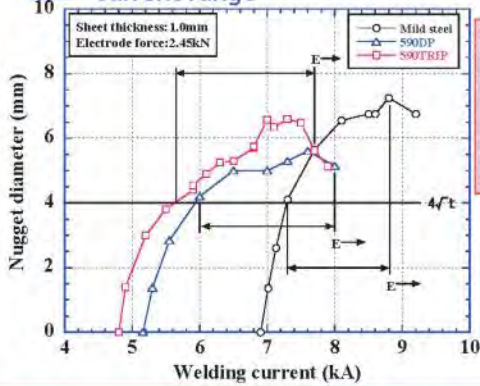
d) Joint strength changes with increase of base steel strength.

Effect of temperature on electric resistance of steel sheets



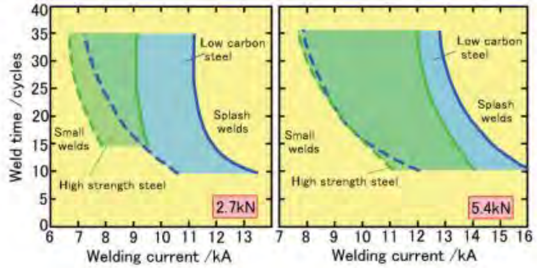
1) Electric resistance of iron increases with increase of amount of additional elements. Therefore, electric resistance of each steel sheet is different.
2) Electric resistance of each steel sheet increases with increase of temperature.

Effect of steel types on suitable welding current range



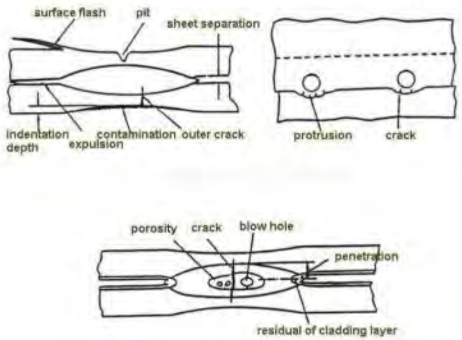
Suitable welding current range of steel sheet (from $4t^{1/2}$ nugget to expulsion) shifts to lower current side with increase of electric resistance of steel sheet.

Shift of suitable welding current area by increase of electrode force

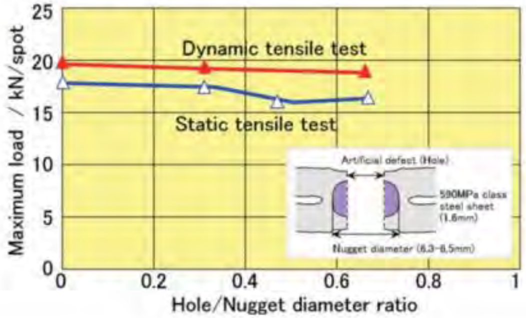


Titanium added high strength steel sheet (2.0mm)

Imperfection(defect)



Influence of the failure in nugget on the joint strength



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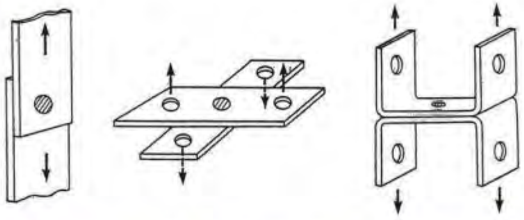
Mechanical testing methods of spot welding



(a) **Tensile shear test** (b) **Cross tension test** (c) **U-tensile test**

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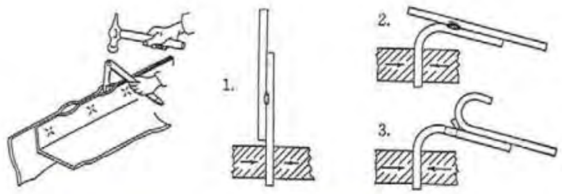
Soundness test of spot welding



(a) **Chisel Test** (b) **Peel Test**

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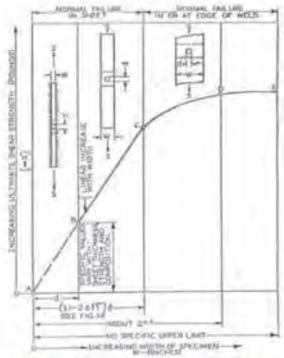

Fig. 4—General Influence of Width of Specimen Upon Spot-Weld Shear Strength (Constant Weld Diameter)

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Safety


41
END
The Japan Welding Technology Center
2016/10

D-1-20. International Standard (ISO 669)

INTERNATIONAL STANDARD

ISO 669

Second edition
2000-04-15

Corrected and reprinted
2001-03-15

Resistance welding — Resistance welding equipment — Mechanical and electrical requirements

Soudage par résistance — Matériel de soudage par résistance — Exigences mécaniques et électriques

Reference number
ISO 669:2000(E)

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Contents

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 669 was prepared by Technical Committee ISO/TC 44, *Welding and allied processes*, Subcommittee SC 6, *Resistance welding*.

This second edition cancels and replaces the first edition (ISO 669:1981), which has been technically revised.

Annex A forms a normative part of this International Standard. Annex B is for information only.

Resistance welding — Resistance welding equipment — Mechanical and electrical requirements

1 Scope

This International Standard applies to resistance welding equipment, to guns with inbuilt transformers and to complete movable welding equipment.

The following types are included:

- single-phase equipment with alternating welding current;
- single-phase equipment with rectified welding current by rectification of the output of the welding transformer;
- single-phase equipment with inverter welding transformer;
- three-phase equipment with rectified welding current by rectification of the output of the welding transformer;
- three-phase equipment with a current rectification in the input of the welding transformer (sometimes called frequency convertor);
- three-phase equipment with inverter welding transformers.

This International Standard applies neither to welding transformers sold separately nor to safety requirements.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 865:1981, *Slots in platens for projection welding machines*.

ISO 5183-1:1998, *Resistance welding equipment — Electrode adaptors, male taper 1:10 — Part 1: Conical fixing, taper 1:10*.

ISO 5183-2:1988, *Resistance spot welding — Electrode adaptors, male taper 1:10 — Part 2: Parallel shank fixing for end-thrust electrodes*.

ISO 5184:1979, *Straight resistance spot welding electrodes*.

ISO 5821:1979, *Resistance spot welding electrode caps*.

ISO 5826:1999, *Electric resistance welding — Transformers — General specifications applicable to all transformers*.

ISO 5829:1984, *Resistance spot welding — Electrode adaptors, female taper 1:10.*

ISO 5830:1984, *Resistance spot welding — Male electrode caps.*

ISO 8430-1:1988, *Resistance spot welding — Electrode holders — Part 1: Taper fixing 1:10.*

ISO 8430-2:1988, *Resistance spot welding — Electrode holders — Part 2: Morse taper fixing.*

ISO 8430-3:1988, *Resistance spot welding — Electrode holders — Part 3: Parallel shank fixing for end thrust.*

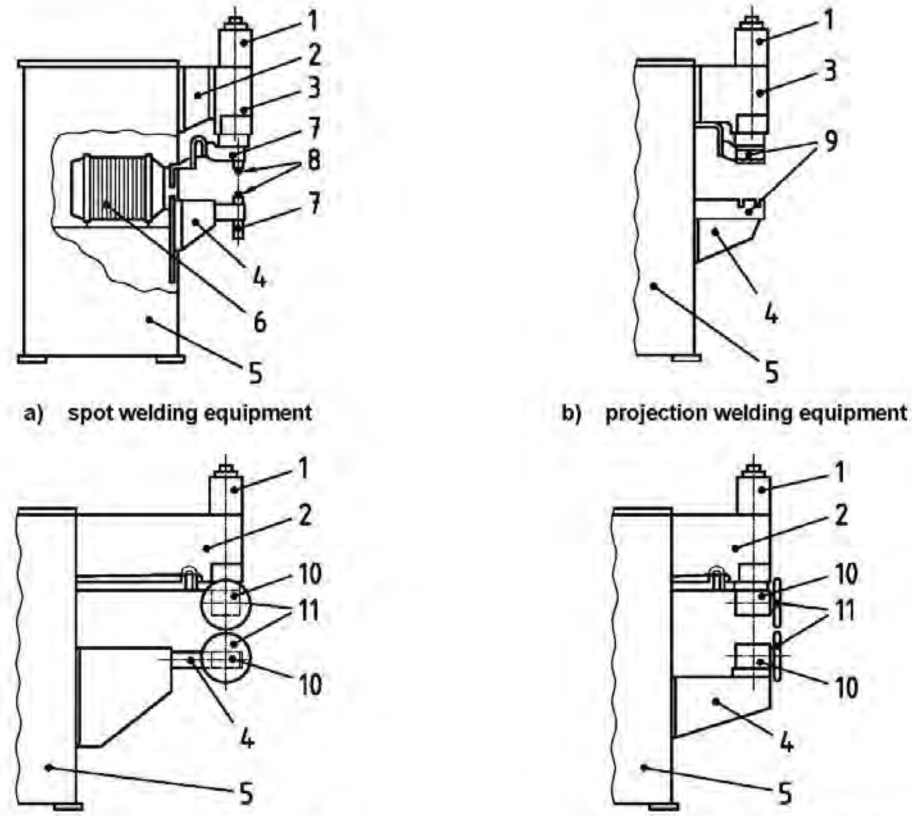
IEC 60051-2:1984, *Direct acting indicating analogue electrical measuring instruments and their accessories — Part 2: Special requirements for amperemeters and voltmeters.*

IEC 60204-1:1992, *Electrical equipment of industrial machines — Part 1: General requirements.*

3 Terms and definitions

For the purposes of this International Standard, the following terms and definitions apply.

3.1 Mechanical parts of spot, projection and seam welding equipment



a) spot welding equipment

b) projection welding equipment

longitudinal seam welding equipment

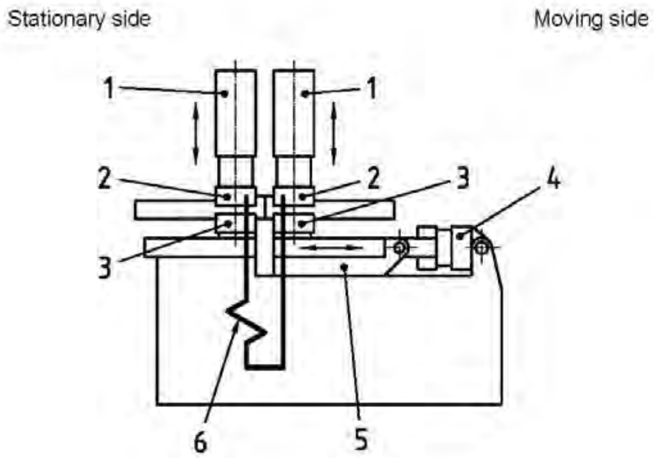
transverse seam welding equipment

c) seam welding equipment

Key

1 Force generation system
2 Upper arm
3 Welding head
4 Lower arm
5 Frame
6 Transformer
7 Electrode holder
8 Electrode
9 Platen
10 Wheel head
11 Electrode wheel

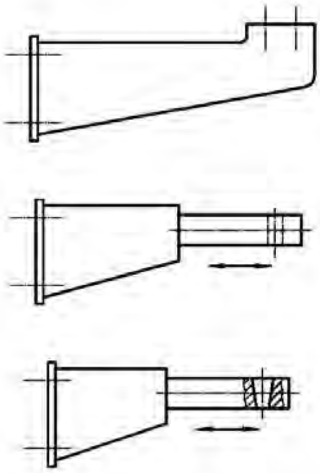
Figure 1 — Elements of spot, projection and seam welding equipment



Key

1 Clamping device
2 Clamping die
3 Current-currying clamping die
4 Slide drive
5 Slide
6 Welding transformer

Figure 2 — Elements of butt welding equipment

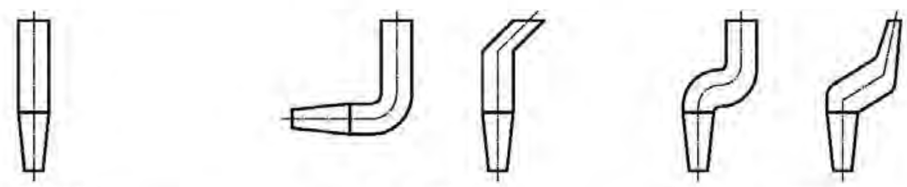


a) not adjustable

b) adjustable with mounting for an electrode holder

c) adjustable for mounting for a spot welding electrode

Figure 3 — Arms (lower arms)



a) straight **b) bent** **c) cranked**

Figure 4 — Spot welding electrodes with male taper at mounting end and flat tip

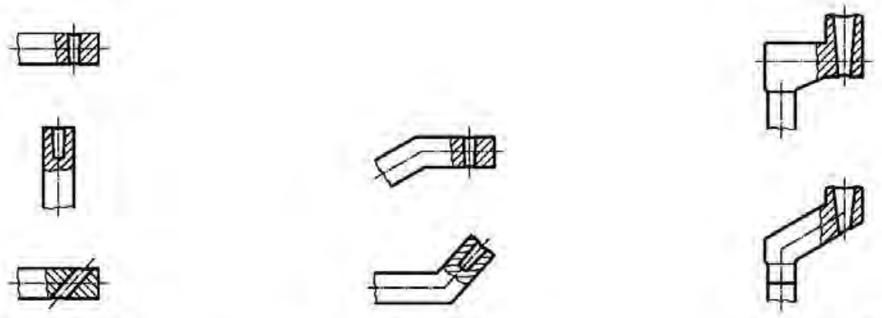


Figure 5 — Electrode holders with female taper for spot welding electrodes (fluid cooling is not illustrated)

3.1.1
arm
device that transmits the electrode force and conducts the welding current or supports a separate conductor

See Figures 1 and 3.

3.1.2
welding head
device comprising the force generation and guiding system carrying an electrode holder, platen or electrode wheel head mounted to the upper arm or directly to the machine body

See Figure 1.

3.1.3
electrode holder
device holding a spot welding electrode or an electrode adaptor 5

[ISO 8430-1, ISO 8340-2 and ISO 8340-3]

See Figures 1 and 5.

3.1.4
spot welding electrode
electrode designed for spot welding

[ISO 5184]

See Figures 1 and 4.

3.1.5
electrode adaptor
device holding an electrode cap by means of male or female taper

[ISO 5183-1, ISO 5183-2 and ISO 5829]

3.1.6
electrode cap
replaceable working end of the spot welding electrode mounted on the electrode adaptor by means of its female or male taper

[ISO 5821 and ISO 5830]

3.1.7
platen
device normally having tee slots and carrying projection welding electrodes or welding tools

[ISO 865]

See Figure 1.

3.1.8
electrode wheel head
device comprising an electrode wheel bearing and mounted on the upper and lower arm for longitudinal and/or transversal seam welding

See Figure 1.

3.1.9
electrode wheel bearing
device guiding the electrode wheel for force transfer and mostly for current transfer

3.1.10
electrode wheel
electrode as a rotating disc

See Figure 1.

NOTE This device may be driven by a motor or moved by the workpiece (idler wheels). The driver may be direct to the electrode shaft or to its circumference (knurl drive), see Figure 6.

3.1.11
electrode wheel profile
form of the electrode wheel being single or double sided bevelled, or radiused depending on the welding conditions and access

See Figure 7.

3.1.12
electrode wheel speed
⟨direct drive⟩ the speed of rotation n

3.1.13
electrode wheel speed
⟨knurl drive⟩ the tangential speed v

3.1.14
throat gap
e
⟨spot and seam welding equipment⟩ usable distance between the arms or the outer current-conducting parts of the welding circuit

See Figure 8.

3.1.15
throat gap
e
⟨projection welding equipment⟩ clamping distance between the platens

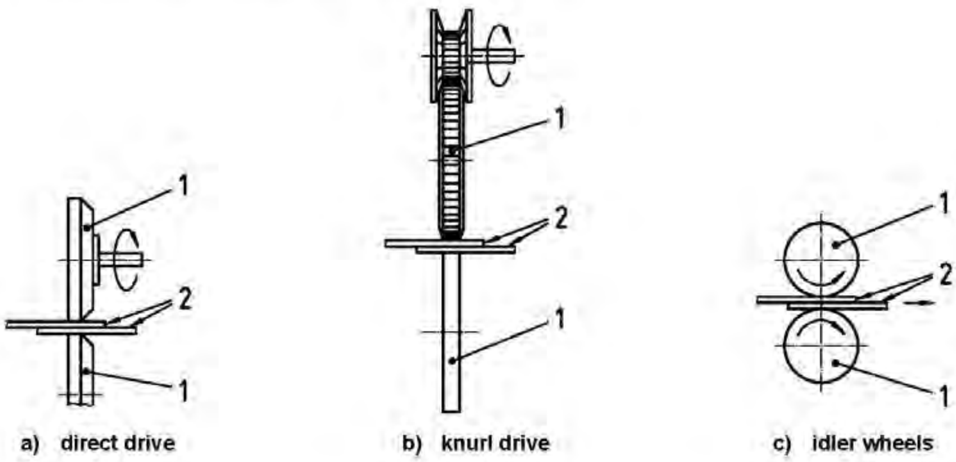
See Figure 8.

NOTE See also die distance, e_1 3.2.11.

3.1.16
throat depth
l
usable distance from the centre of the platens or the axes of the electrodes or, in the case of oblique electrodes, the point of intersection of the electrode axes in the working position or the contact line of electrode wheels and that part of the equipment body located closest to it

See Figure 8.

NOTE This definition does not consider any offset of the electrode tips.



Key
1 Electrode wheel
2 Components to be welded

Figure 6 — Drive types of electrode wheels

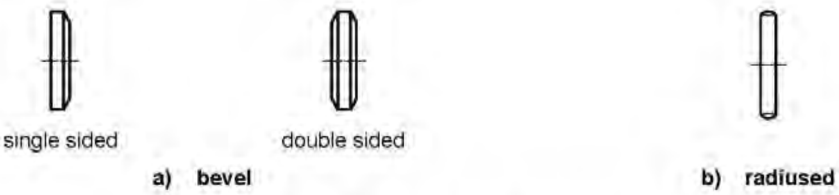
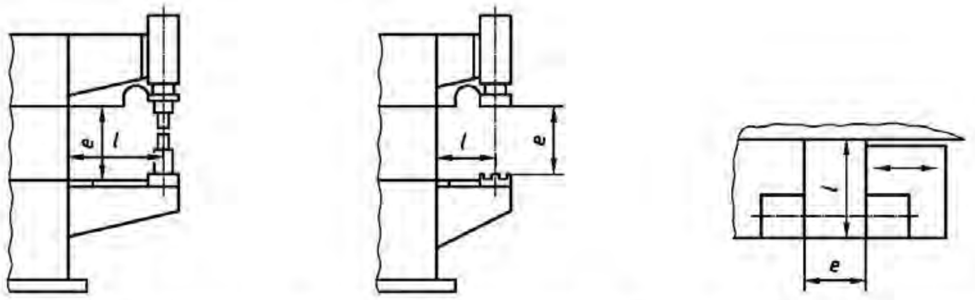


Figure 7 — Profiles of electrode wheel



a) spot welding equipment   b) projection welding equipment   c) butt welding equipment (top view)

Figure 8 — Main dimensions

3.1.17
electrode stroke
c
physical displacement of electrodes during process function

NOTE 1 When the electrode is attached to the driving cylinder, the stroke of both the electrode and the driving cylinder, is equal.

NOTE 2 When the moving electrode is attached to a hinged lever moved by a driving cylinder, the maximum stroke of the electrode, by convention, equals the length of the chord of the arc generated by the tip of the moving electrode for the full stroke of the driving cylinder.

NOTE 3 The stroke of the electrode may be composed of a "work clearance stroke" without any contact, facilitating the introduction of the workpiece between the electrodes and a smaller "working stroke".

3.1.18
electrode force
F
force to the workpiece transmitted by the electrodes

3.1.19
maximum electrode force
F_{max}
maximum electrode force, which can be generated by the welding equipment without permament damage to its mechanical parts

3.1.20
minimum electrode force
F_{min}
minimum electrode force which can be used for proper functionning of the welding equipment

3.2 Mechanical parts of butt welding equipment

3.2.1
slide drive
drive generating and transferring the movements and upset forces necessary for welding to a workpiece located in the clamping device

NOTE For flash welding the drive may be required to reciprocate the slide for preheating by following the flashing movement and to provide the upset force.

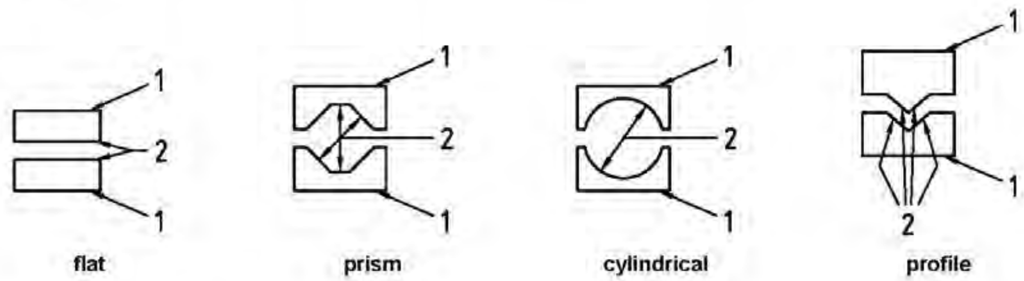
3.2.2
clamping device
device generating the contact force necessary for current flow and providing the clamping force necessary to withstand the upset force if no supplementary clamping devices or backstops exist

3.2.3
supplementary clamping device
non-current-carrying device to provide the clamping force necessary to resist the upset force

3.2.4
backstop
device to support the total or a part of the upsetting force to a workpiece in order to prevent a workpiece from sliding during upsetting

3.2.5
clamping die
device designed to transfer all forces to the workpiece in contacting with its clamping face

See Figure 9.



Key

1 Mounting or support face

2 Contact and/or clamping face

Figure 9 — Types of clamping dies
(illustrated in upsetting direction)

3.2.6
die length
G
usable length of a clamping die in the upsetting direction

See Figure 10.

3.2.7
die width
W
usable width of a clamping die perpendicular to the upsetting and clamping direction

See Figure 10.

3.2.8
die thickness
δ
dimension in the clamping direction

See Figure 10.

3.2.9
die stroke
q
difference between the smallest and largest opening gap

See Figure 10.

3.2.10
opening gap
f
usable distance between flat clamping faces

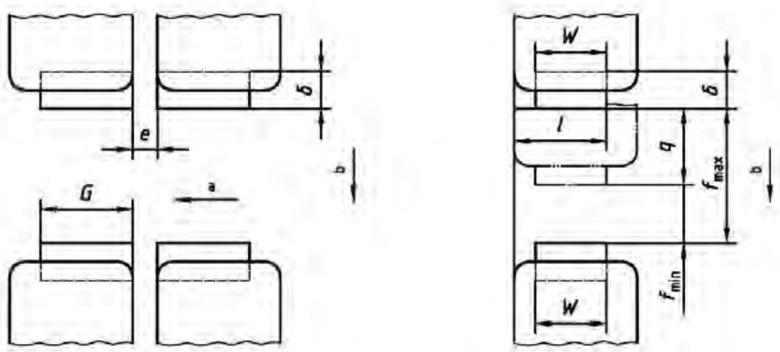
See Figure 10.

NOTE If the workpiece has to be loaded perpendicular to the upsetting direction, the usable gap of profile dies is smaller than flat dies, see Figure 9

3.2.11
distance
e
the clear distance between both die pairs in upsetting direction

See Figure 10.

NOTE See also throat gap, *e*, 3.1.14 and 3.1.15.



view perpendicular to clamping and upsetting direction

view in upsetting direction

[a] Upsetting direction

[b] Clamping direction

Figure 10 — Die measurements

3.2.12
upsetting stroke
difference between the smallest and largest die distance

3.2.13
throat depth
l
distance perpendicular to the direction of the upsetting force between the machine body and the outer edge of the clamping dies

See Figures 8 and 10.

3.2.14
clamping force
F_2
force applied to the workpiece by the clamping dies

3.2.15
maximun clamping force
$F_{2\text{max}}$
maximum force, acting through the dies on each part to be assembled, to prevent any sliding and to maintain good electrical contact with the electrodes when the maximum upsetting force is applied

3.2.16
upsetting force
F_1
force acting in the upsetting direction to press the workpieces together

3.2.17
maximum upsetting force
$F_{1\text{max}}$
maximum upsetting force which can be generated by the welding equipment without damage to its mechanical parts

3.2.18
minimum upsetting force
$F_{1\text{min}}$
minimum upsetting force which can be used for proper functioning of the welding equipment

3.2.19
preheating force
F_{c1}
force acting in the upsetting direction during preheating

3.2.20
upsetting pressure
p_{F1}
pressure created by the upsetting force, concerning the welding cross-section

3.3 Static mechanical, electrical and thermal characteristics

3.3.1
contact faults
faults relating to the eccentricity and deflection

3.3.2
eccentricity
g
distance to which the central points of the electrode working faces or the clamping platens are displaced in relation to each other by the electrode force

See Figures 11 and 12.

NOTE 1 The eccentricity of spot and seam welding equipment (see Figure 11) is calculated by the following formula:

$$g = b - a$$

NOTE 2 The eccentricity of projection welding equipment (see Figure 12) is measured in accordance with 15.2.2.

3.3.3
deflection
α
angle to which the electrode axes, the clamping platen faces or the workpiece axes deviate from their intended position due to the electrode or upsetting force

See Figures 11, 12 and 13.

NOTE 1 The deflection of spot and seam welding equipment (see figure 11) is calculated by the following formula:

$$\alpha = \alpha_2 - \alpha_1$$

NOTE 2 The deflection of projection welding equipment (see figure 12) is calculated by the following formula:

$$\alpha \approx \tan\alpha = \frac{b_1 - b_2}{b_3}$$

NOTE 3 The deflection of butt welding equipment (see figure 13) is calculated by the formula:

$$\alpha \approx \tan\alpha = \frac{b}{k}$$

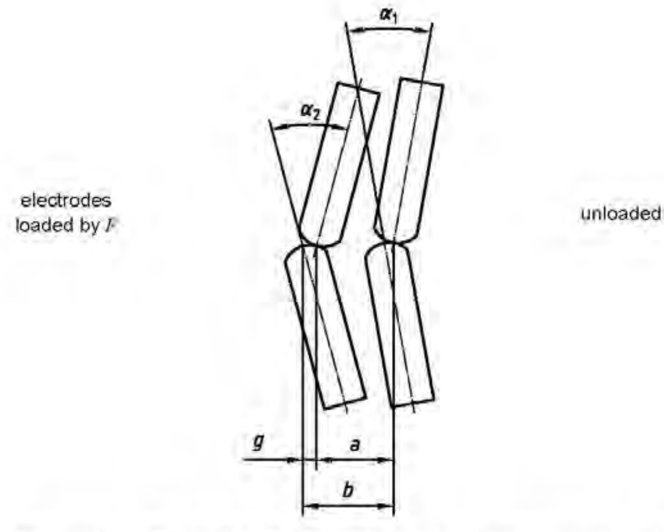


Figure 11 — Contact fault of spot and seam welding equipment

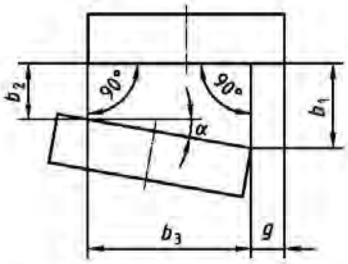


Figure 12 — Contact fault of projection welding equipment

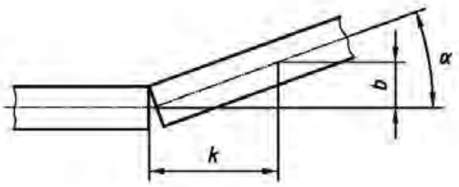


Figure 13 — Contact fault of butt welding equipment

3.3.4
duty
schedule of the operating conditions of equipment (their respective durations and sequences)

3.3.5
continuous duty
duty corresponding to a permanent on-load operation, without any interruption in which case the duty cycle is 100 %

3.3.6
periodic duty
repeated identical cycles of a constant load and a no-load time, the sum of one load time and one no-load time being the weld cycle time

NOTE This International Standard considers the load to be constant, i.e. without any pre-heating and/or post-heating period.

3.3.7
duty factor
X
ratio for a given interval of the on-load duration to the total time

NOTE This ratio, lying between 0 and 1, may be expressed as a percentage.

3.3.8
rated supply voltage
U_{1N}
supply voltage for which the equipment is constructed

3.3.9
rated no-load voltage at the output
U_{20}, U_{2di} or U_{2d}

3.3.9.1
ac no-load voltage
U_{20}
voltage of one output winding of the transformer when the external circuit is open and the rated supply voltage is applied to the input terminals

NOTE Several settings of the input winding result in relevant values of the no-load voltage.

3.3.9.2
dc no-load voltage
U_{2di}
calculated voltage at the output, when the rated supply voltage is applied to the input terminals, ignoring rectifier voltage drop

NOTE U_{2di} depends on the rectifying circuit.

3.3.9.3
dc no-load voltage
U_{2d}
(inverter type equipment) voltage of the output when the rated supply voltage is applied to the input terminals

3.3.10
permanent supply current
I_{1p} or I_{Lp}
supply current corresponding to the permanent output current

NOTE The relationship between input and output currents depend on the type of welding equipment.

3.3.11
permanent output current
I_{2p}
highest output current on all settings of the regulator, for continuous operation (100 % duty factor)

3.3.12
permanent power
S_p
maximum electrical input power for 100 % duty factor without the equipment exceeding the specified temperature rise

3.3.13
maximum time per pulse
t_i
time during which the output current may flow without interruption at a given output current or voltage adjustment

NOTE This time is limited

— by the saturation of the magnetic circuit for welding equipment with rectification of the input or

— by the heat rise of the rectifier for welding equipment with rectification of the output.

3.3.14
supply current at a given duty factor
I_{1X} or I_{LX}
the maximum input current when operating at a given duty factor X, without the equipment exceeding the specified temperature rise, the maximum setting of the output voltage being given by:

$$I_{1X} = I_{1p}\sqrt{\frac{100}{X}}$$ for single phase transformers

or

$$I_{LX} = I_{Lp}\sqrt{\frac{100}{X}}$$ for three phase transformers

3.3.15
maximum short-circuit current input
I_{1cc} or I_{Lcc}
root mean-square (rms) value of the current at rated supply voltage at the highest output voltage tapping, the electrodes being short-circuited in accordance with clause 10 and the two values given correspond to the minimum and maximum value of the impedance compatible with this method of short circuit

NOTE I_{Lcc} is used for welding equipment with rectification.

3.3.16
maximum short-circuit current output
I_{2cc}
root mean-square (rms) value of the current at rated supply voltage at the highest output voltage tapping, the electrodes being short-circuited in accordance with clause 10 and the two values given correspond to the minimum and maximum value of the impedance compatible with this method of short circuit

3.3.17
supply pressure of the energizing medium
p_1
pressure at the supply point of the welding equipment

3.3.18
pressure of the energizing medium
p_2
pressure in the driving cylinder or cylinders to obtain maximum force

3.3.19
rated cooling liquid flow
Q
total quantity of cooling liquid to operate the equipment at permanent power without exceeding the temperature rise limits

3.3.20
cooling liquid pressure drop
Δp
pressure drop at the rated cooling liquid flow

3.4 Dynamic mechanical characteristics

See annex A.

4 Symbols

The symbols used in this International Standard are listed in Table 1.

Table 1 — Symbols and their designations

Symbol	Designation	Reference
a	length for determination of the contact fault	3.3.2
$a_{1,2}$	lengths for determination of the deflection	15.3
b	length for determination of the contact fault	3.3.2, 3.3.3
$b_{1,2,3}$	lengths for determination of the contact fault	3.3.3, 15.2, 15.3, 15.4
c	stroke of electrode	3.1.17, 15.1
d	diameter of the tip of electrode or width of the electrode wheels	10.2
d_k	disc diameter	15.2
D_1	ball diameter	15.2
e	1) throat gap 2) platen distance 3) die distance	3.1.14, 3.1.15, 15.1, 16.3 3.1.15,16.3 3.2.11, 10.4, 16.3
e_{min}	minimum platen distance	10.3
e'	distance for calculation of the length of copper bar	10.3
E_a	impact energy	annex A
f	opening gap	3.2.10
f_{max}	maximum opening gap	3.2.11
f_{min}	minimum opening gap	3.2.11
F	electrode force	3.1.18, 10.4
F_{c1}	pre-heating force	3.2.19
F_{max}	maximum electrode force	3.1.19, 10.2, 10.3, 15.1, 16.3
F_{min}	minimum electrode force	3.1.20, 16.3
F_1	upsetting force	3.2.16
F_{1max}	maximum upsetting force	3.2.17, 10.4, 15.1, 16.3
F_{1min}	minimum upsetting force	3.2.18, 16.3
F_2	clamping force	3.2.14
F_{2max}	maximum clamping force	3.2.15, 10.4, 15.4, 16.3
F_{2min}	minimum clamping force	16.3
$F_{1f}...F_{3f}$	force oscillations during follow up	annex A
$F_{1s}...F_{3s}$	force oscillations after electrode contact	annex A
F_1', F_2'	opposite forces	15.2
g	eccentricity	3.3.2, 15ff, 16.2, 16.3
$g_{10, 50, 100}$	eccentricity at 10 %, 50 % or 100 % of the maximum force	16.3
G	die length	3.2.6, 3.2.11
I_{1cc}	maximum input short circuit current	3.3.15
I_{1p}	input permanent current	3.3.10
I_{1X}	input current at a given duty factor	3.3.14
I_{2cc}	maximum output short circuit current	3.3.16, 16.3
I_{2p}	permanent output current to a 100 % duty factor	3.3.11, 16.3
I_{Lcc}	maximum line short circuit current	3.3.15
I_{Lp}	permanent line current	3.3.10
I_{LX}	line current at a given duty factor	3.3.14

Table 1 (*continued*)

Symbol	Designation	Reference
k	distance for determination of deflection	3.3.3, 15.3, 15.4
K_{F}	coefficient of force	annex A
K_{Fs}, K_{Ff}	electrode contact/follow up force coefficient	annex A
l	throat depth	3.1.14, 3.1.15, 3.1.16, 3.2.13, 15.1, 16.3
l_{sc}	length of copper bar	10.3, 10.4, 15.4
l'	length of copper bar	10.3
m	mass of the welding head	annex A
n	speed of rotation	3.1.12, 16.3
p_1	supply pressure of the energizing medium	3.3.17, 16.3
p_2	pressure of the energizing medium	3.3.18, 16.3
p_{F1}	upsetting pressure	3.2.20
q	die stroke	3.2.9, 3.2.11
Q	rated cooling liquid flow	3.3.19, 16.3
S_{p}	permanent input power (100 % duty factor)	3.3.12, 16.3
S_{50}	input at 50 % duty factor	16.3
t	impulse time	annex A
t_{a}	force rise time	annex A
t_{fd}	decay time during follow up	annex A
t_{i}	maximum time per pulse	3.1.15, 3.3.13
t_{sd}	decay time after electrode contact at A	annex A
T_1	temperature of the cooling medium	12.2
U_{1N}	rated supply voltage	3.3.8, 9, 16.3
U'_{1N}	supply voltage	9
U_{20}	rated ac no-load voltage	3.3.9.1, 9, 16.3
U'_{20}	ac no-load voltage	9
U_{2d}	rated dc no-load voltage from inverter type welding equipment	3.3.9.3, 9, 16.3
U_{2di}	rated dc no-load voltage	3.3.9.2, 9, 16.3
v	tangential speed	3.1.13, 16.3
v_{a}	impact velocity	annex A
W	die width	3.2.7, 3.2.11, 10.4
X	duty factor	3.3.7, 3.3.14
α	deflection	3.3.3, 15ff, 16.2
$\alpha_{1, 2}$	angles for determination of the deflection	3.3.3, 15.3
$\alpha_{10, 50, 100}$	deflection at 10 %, 50 % or 100 % of the maximum force	16.3
Δp	pressure drop of the cooling liquid circuit	3.3.20, 16.3
δ	die thickness	3.2.8, 3.2.11

5 Classification

Resistance welding equipment is classified as:

a) spot welding equipment [(see Figure 1a)];

b) projection welding equipment [(see Figure 1b)];

c) seam welding equipment [(see Figure 1c)];

d) butt welding equipment [(see Figure 2)].

NOTE Flash welding equipment is a special type of butt welding equipment.

6 Physical environment and operating conditions

6.1 General

Welding equipment shall be suitable for use in the physical environment and operating conditions specified below.

When the physical environment and/or operating conditions are outside those specified below, an agreement may be needed between the supplier and the user (see annex B of IEC 60204-1:1992).

6.2 Ambient air temperature

Welding equipment shall be capable of operating correctly in an ambient air temperature of between + 5 °C and + 40 °C.

For maximum temperatures of the cooling medium see annex C of ISO 5826:1999.

6.3 Humidity

Welding equipment shall be capable of operating correctly with a relative humidity up to 95 %.

Harmfull effects of occasional condensation shall be avoided by proper design of the welding equipment or, where necessary, by proper additional measures (e.g. built-in heaters, air conditioners, drain holes).

6.4 Altitude

Welding equipment shall be capable of operating correctly at altitudes up to 1 000 m above mean sea level.

For other altitudes see annex C of ISO 5826:1999.

6.5 Transportation and storage

Welding equipment shall be designed to withstand, or suitable precautions shall be taken to protect against, transportation and storage temperatures between – 25 °C and + 55 °C and for short periods not exceeding 24 h up to + 70 °C.

Suitable means shall be provided to prevent damage from humidity, vibration and shock.

6.6 Provisions for handling

Heavy and bulky electrical equipment that has to be removed from the welding equipment for transport, or which is independent of the welding equipment, shall be provided with suitable means for handling by cranes or similar equipment.

7 Test conditions

The tests shall be carried out on new, dry and completely assembled welding equipment at an ambient air temperature of between + 10 °C and + 40 °C. The ventilation shall be identical with that prevailing under normal service conditions. The measuring devices used shall not interfere with the normal ventilation of the welding equipment or cause abnormal transfer of heat to or from it.

Liquid cooled welding equipment shall be tested with cooling liquid conditions as specified by the manufacturer.

The accuracy of measuring instruments shall be:

a) electrical measuring instruments: Class 1 (1 % full scale, see IEC 60051-2), appropriate for short time measurements, for a.c. current true rms meter;

   Electrical measurements shall be made under full-wave, non transient conditions.

b) thermometer: ± 2 K.

Unless otherwise specified, the tests required in this International Standard are type tests.

8 Welding transformers

Resistance welding transformers shall comply with ISO 5826.

Compliance shall be checked in accordance with ISO 5826.

9 Rated no-load voltage at the output

The rated no-load voltage shall be given for all settings within a tolerance of ± 2 %.

Compliance shall be checked:

a) in case of a.c. by measurement of U_{20};

NOTE If the supply voltage U'_{1N} differs from the rated supply voltage U_{1N}, the no-load voltage U'_{20} is measured. The rated no-load voltage (U_{20}) is calculated by the formula:

$$U_{20} = U'_{20} \frac{U_{1N}}{U'_{1N}} \text{ in volts}$$

b) in case of dc by calculation of U_{2di} in accordance with Table 2;

Table 2 — "Ideal" dc no-load voltage

Input	Output	U_{2di}
⅄	*	1,17 U_{20}
Δ	*	1,35 U_{20}
single phase	mid point	0,9 U_{20}
frequency converter primary rectifying		1,35 U_{20}

c) in case of d.c. from inverter type welding equipment by measurement of U_{2d}.

10 Maximum short circuit current

10.1 General

The maximum short-circuit current shall be given with the following tolerances:

a) direct measurement: ± 5 %;

b) indirect measurement: $^{+10}_{\ 0}$ % (calculation from input measurement).

The short-circuit shall be affected by copper having a conductance of at least 45 S.

Compliance shall be checked by measurement according to the conditions given in

— 10.2 for spot- and seam-welding equipment;

— 10.3 for projection welding equipment;

— 10.4 for butt welding equipment.

The following measurements are made successively:

a) for the minimum value of impedance (throat gap and throat depth are minimum);

b) for the maximum value of impedance (throat gap and throat depth are maximum).

10.2 Spot- and seam-welding equipment

The electrodes or the rotating electrode wheels are brought into contact by applying the maximum electrode force F_{max} according to the arm length in use. The diameter, d, of the tip of the electrodes or the width of the electrode wheels is related to the electrode force according to the following formula, but it shall be at least 2,5 mm.

$$d = 0{,}16\sqrt{F_{max}} \pm 5\ \%\ \text{in millimetres}$$

where F_{max} is in newtons.

10.3 Projection welding equipment

Between, and directly under, the centre of the platens, a copper bar is placed with a cross section sufficient to prevent overheating. The maximum electrode force F_{max} is applied.

The free length of the copper bar L_{sc} or L' is calculated by the following formulae, but it shall be at least equal to $e' = e_{min} + 5$ in millimetres.

$$L_{sc} = 122\, F_{max} . 10^{-5} + 75 \text{ in millimetres}$$

$$L' = L_{sc} + e' \text{ in millimetres}$$

where e' is in millimetres and F_{max} is in newtons.

10.4 Butt welding equipment

Between the dies, a copper bar is placed of section sufficient to prevent overheating. The contact surfaces shall be as large as possible. The maximum clamping force F_{2max} is applied.

L_{sc}, the length of the copper bar between the opposed faces of the dies (see Figure 14), is given by the following formula, but it shall be at least equal to $e + 5$ in millimetres.

$$L_{sc} = 1{,}5 \frac{F}{W} + 2 \text{ in millimetres}$$

With preheating is:

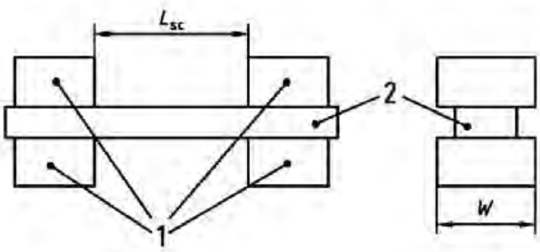
$$F = \frac{F_{1max}}{30} \text{ in newtons}$$

Without preheating is:

$$F = \frac{F_{1max}}{150} \text{ in newtons}$$

where W is in millimetres and F_{1max} is in newtons.

For operations with both with preheating and without preheating the lower value of L_{sc} is used.



Key

1 Die

2 Copper bar

Figure 14 — Short circuit bar for butt welding equipment

11 Thermal rating

The thermal rating shall be:

a) for transformers, in accordance with ISO 5826;

b) for accessible surfaces, in accordance with Table 3;

c) for cooling media, as given by the manufacturer.

If the rated supply voltage is not available, the test can be made with reduced voltage on agreement between manufacturer and purchaser.

Welding equipment with current rectification shall be tested with the rated supply voltage.

Compliance shall be checked:

1) for transformers — by measurement in accordance with 6.2 of ISO 5826:1999;

2) for accessible surfaces — by measurements immediately before the last loading in accordance with 12 and 13.1;

NOTE The highest temperature taken is recorded.

3) for cooling medium — by calculation of the average of the temperature obtained during the last quarter of the test in accordance with 12 and 13.2.

Table 3 —Limits of temperature rise for accessible surfaces

Accessible surface	Temperature rise K
Bare metal enclosures	25
Painted metal enclosures	35
Non-metallic enclosures	45
Metal handles	10
Non-metallic handles	30

12 Heating test

12.1 general

The welding equipment shall be short-circuited according to

— 10.2 for spot- and seam-welding equipment

— 10.3 for projection welding equipment

— 10.4 for butt welding equipment

and operated at the corresponding duty factor at a cycle time according to real operation conditions.

12.2 Beginning of the heating test

The heating test shall be started when:

a) the flow of cooling liquid has started (in case of liquid-cooled welding equipment);

b) the welding equipment has reached a thermal balance with the cooling medium within ± 1 K;

c) the temperature of the cooling medium, T_1 , is retained as initial temperature of the winding whose resistance is being measured.

NOTE Except when the temperature of a part is determined by the resistance method the test may be started without the welding equipment having reached a temperature balance with the ambient air.

12.3 Duration of the heating test

The heating test shall be carried out until the rate of the temperature rise of any component does not exceed 2 K/h.

13 Conditions for the measurement of temperature rise

13.1 Accessible surfaces

The temperature rise of other parts than the transformer are measured with appropriate thermosensitive elements that are in the closest possible contact with the part whose temperature rise is to be verified. They are placed at the hottest accessible point.

13.2 Cooling medium

13.2.1 Ambient air

The temperature of the ambient air shall be determined by at least three measuring devices, spaced uniformly around the welding equipment, at a distance of 1 m to 2 m from it and at approximately one-half the height of the welding equipment.

They shall be shielded from heat and draughts.

NOTE The thermometer bulbs may be placed in small holders filled with oil with a view to equalizing the temperature variations.

13.2.2 Cooling liquid

The temperature of the cooling liquid shall be measured where this enters the welding equipment.

14 Cooling liquid circuit (liquid-cooled welding equipment)

Cooling liquid circuits shall enable a sufficient flow in order to ensure efficient cooling.

The cooling liquid circuit shall be tight at a pressure of 10 bar for 10 min and may have a pressure drop up to the value stated on the rating plate.

Compliance shall be checked by leak-tightness and flow checking.

15 Static mechanical characteristics

15.1 General

The following static mechanical characteristics are recommended to be given in agreement between the manufacturer and the purchaser:

a) for spot, projection and seam welding equipment:

   1) eccentricity g in millimetres and

   2) deflection α in milliradians;

b) for butt welding equipment:

   1) deflection α in milliradians.

Compliance shall be checked by measurement with:

a) 10 %,

b) 50 % and

c) 100 %

of the maximum electrode force F_{max} (see 3.1.19) or upsetting force F_{1max} (see 3.2.17) at the maximum adjustment of the:

d) electrode stroke c (see 3.1.17),

e) throat depth l (see 3.1.16) and

f) throat gap e (see 3.1.14 and 3.1.15).

The measurements are carried out according to:

— 15.2 for spot and projection welding equipment;

— 15.3 for seam welding equipment;

— 15.4 for butt welding equipment.

NOTE The results are given as absolute values. If the deflection reverses when the force is increased, this is indicated by plus or minus as appropriate.

15.2 Spot and projection welding equipment

15.2.1 General

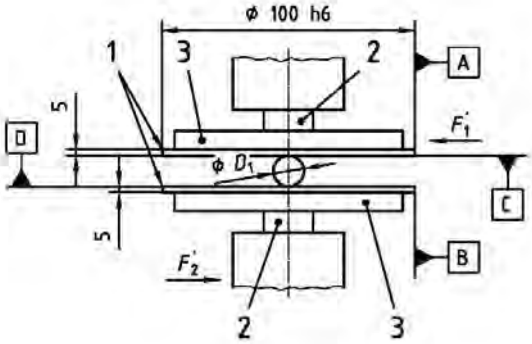
Two hardened discs, as shown Figures 15 and 16, are placed with their plugs (instead of spot welding electrodes) or with their flanges at the centre of the platens in such a way that their opposite faces are parallel and the eccentricity does not exceed 0,05 mm. A steel ball is placed between the two hardened discs and centred using an appropriate flexible device.

NOTE 1 The hardened discs are machined to a tolerance of h6.

NOTE 2 The diameter of the ball D_1, and the material used for the hardened discs are chosen so that no impression appears on the contact faces at maximum force.

NOTE 3 The contact faces, in particular, should be of hardened steel.

Dimensions in millimetres



Key

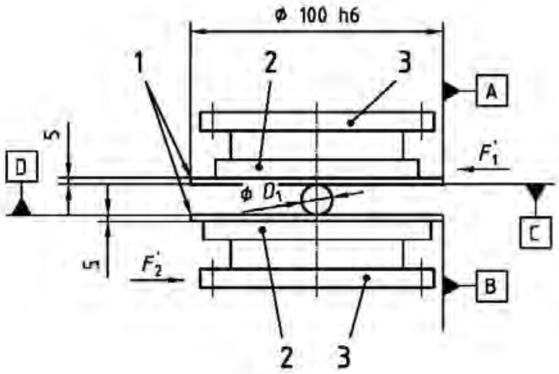
1 Hardened disc

2 Plug

3 Support

Figure 15 — Measurement accessory for spot welding equipment

Dimensions in millimetres



Key

1 Hardened disc

2 Support

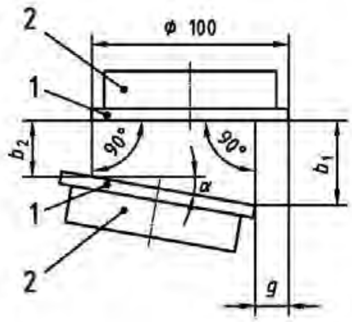
3 Mounting flange

Figure 16 — Measurement accessory for projection welding equipment

15.2.2 Eccentricity

The eccentricity (g) is directly measured with a gauge calibrated to 0,01 mm, see Figure 17.

Dimensions in millimetres



Key

1 Hardened disc

2 Support

Figure 17 — Measurement of eccentricity and deflection

15.2.3 Deflection

The deflection (α) is calculated using the formula:

$$\alpha \approx \tan\alpha = \frac{b_1 - b_2}{100 - g} 1000 \text{ in milliradians}$$

The distances b_1 and b_2 between the hardened discs are measured using thickness gauges with an accuracy unit of 0,01 mm.

NOTE 1 For rocker arm welding equipment, the electrodes should be parallel at the beginning of the test.

NOTE 2 The methods of fixing shown in Figures 15 and 16 are for information only. Plugs may be fitted with adaptors to suit the welding equipment.

NOTE 3 If it is not possible to use discs with a diameter of 100 mm because of the dimensions of the welding equipment, smaller diameters d_k may be used, by agreement with the user. In this case the deflection α is given by the formula:

$$\alpha \approx \tan\alpha = \frac{b_1 - b_2}{d_k - g} 1000 \text{ in milliradians}$$

NOTE 4 In order to estimate the behaviour of the welding equipment when using offset electrodes, the discs may be subjected to the simultaneous application of:

a) the maximum electrode force;

b) two opposite forces F_1' and F_2' equal to 10 % of the appropriate electrode force, in a plane parallel to reference faces C and D (see Figures 15 and 16) in the less favourable direction for the welding equipment.

This measurement is repeated with the forces F_1' and F_2' reversed.

15.3 Seam welding equipment

15.3.1 General

The welding equipment is fitted with electrode wheels that are normally delivered with it. The measurement device consists of a holder with two knife edges that are applied to the lower electrode wheel, see Figure 18.

Using a gauge calibrated to 0,01 mm, the dimensions a_1 and b_1 with no-load, and a_2 and b_2 with load are measured. The distance between $a_{1,\,2}$ and $b_{1,\,2}$ is k, see Figure 18.

15.3.2 Eccentricity

The eccentricity g is calculated using the formula:

$$g = a_1 - a_2 \text{ in millimetres}$$

15.3.3 Deflection

The deflection α is calculated using the formula:

$$\alpha = \alpha_1 - \alpha_2 \text{ in milliradians}$$

$$\alpha_1 \approx \tan\alpha_1 = \frac{b_1 - a_1}{k} 1\,000 \text{ in milliradians and } \alpha_2 \approx \tan\alpha_2 = \frac{b_2 - a_2}{k} 1\,000 \text{ in milliradians}$$

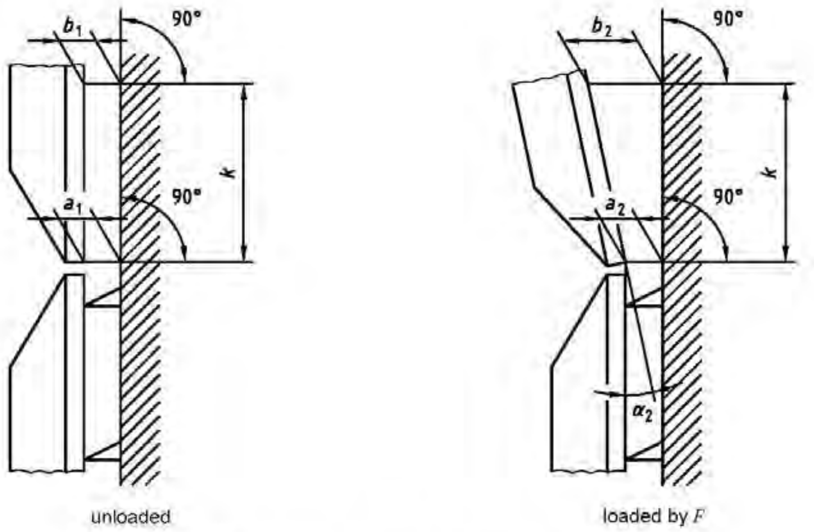


Figure 18 — Measurement arrangement in electrode wheels

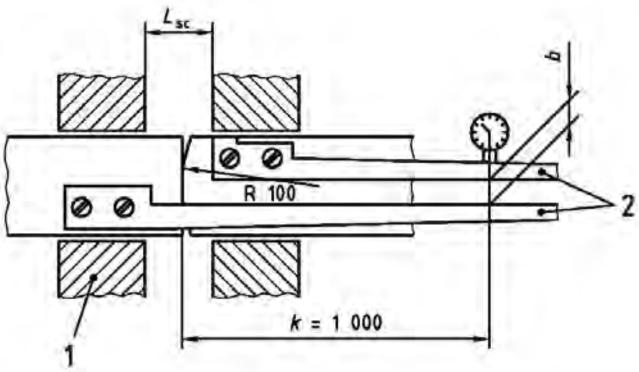
15.4 Butt welding equipment

15.4.1 General

Two bars of steel, having a sectional area equal to the maximum area that can be welded, and each fitted with a graduated scale approximately 1 000 mm in length, are fixed in the dies and placed in contact in such a way that the distance between the dies L_{sc} is as given in 10.4.

These bars are kept in position by application of the maximum clamping force F_{2max}. The contact face of one of the bars shall be curved and of radius R100 mm, see Figure 19.

Dimensions in millimetres



Key

1 Clamping die

2 Graduated straight-edge

Figure 19 — Measurement arrangement for butt welding equipment

Using a gauge calibrated to 0,01 mm, the dimensions b_1 with no-load, and b_2 with load, are measured in the distance k from the plane of the contact, see Figure 19.

15.4.2 Deflection

The deflection α is calculated by the formula:

$$\alpha \approx \tan\alpha = \frac{b_2 - b_1}{k} 1\,000 \text{ in milliradians}$$

For a distance k = 1 000 mm:

$$\alpha \approx \tan\alpha = b_2 - b_1 \text{ in milliradians}$$

16 Rating plate

16.1 General

A clearly and indelibly marked rating plate shall be fixed securely to or printed on each welding equipment.

NOTE The purpose of the rating plate is to indicate to the user the electrical and mechanical characteristics in order to enable the correct selection of the welding equipment and to allow their comparison.

Compliance is checked by visual inspection and by rubbing the marking by hand for 15 s with a piece of cloth soaked with water and again for 15 s with a piece of cloth soaked with petroleum spirit.

After the test the marking shall be easily legible and it shall not be easy to remove the rating plate which shall show no curling.

16.2 Description

The rating plate shall be divided into sections containing information and data for the

a) identification;

b) welding output;

c) mains supply;

d) other characteristics.

The arrangement and sequence of the data shall comply with the principle shown in Figure 20 (for examples see annex B).

The dimensions of the rating plate are not specified and may be chosen freely.

NOTE 1 Additional information (e.g. deflection, eccentricity g, maximum time per impulse t_i) may by given.

NOTE 2 Other useful information may be given in technical litterature supplied by the manufacturer.

16.3 Contents

16.3.1 General

The following data of the welding equipment refer to the numbered boxes shown in Figure 20.

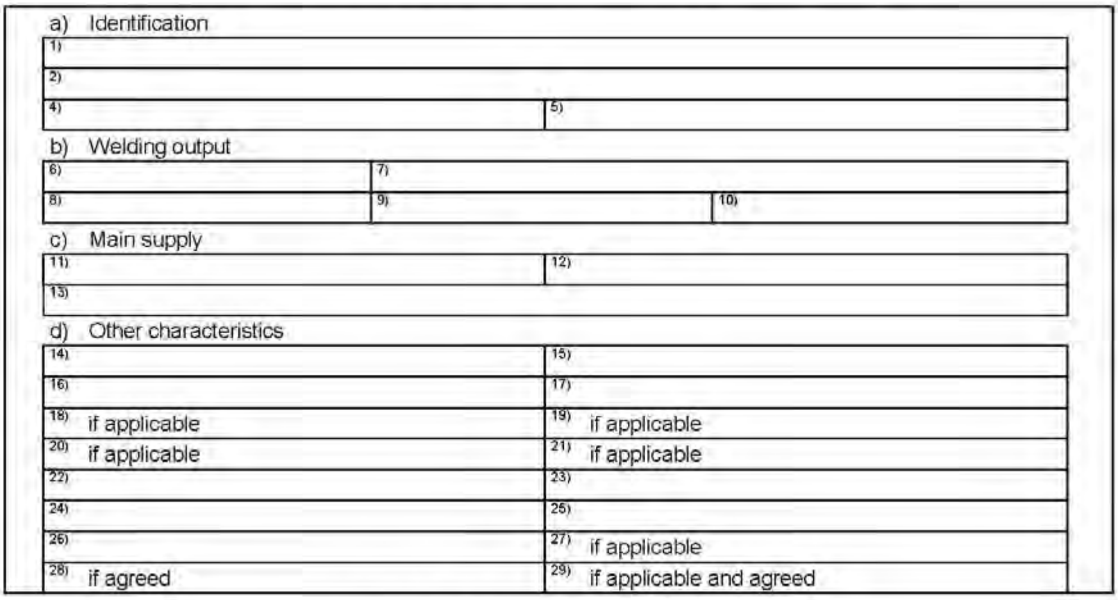


Figure 20 — Principle of the rating plate

16.3.2 Identification:

Box 1 Name and address of the manufacturer or distributor or importer and, optionally, a trademark and the country of origin if required.

Box 2 Type (indentification) as given by the manufacturer.

Box 4 Traceability of design and manufacturing data (e.g. serial number) and year of production.

Box 5 Reference to this International Standard confirming that the welding equipment complies with its requirements.

16.3.3 Welding output

Box 6 Welding current symbol e.g.:

⎓ Direct current (dc) or

~ Alternating current (ac), and additionally the rated frequency in Hz (e.g.: ~ 50 Hz)

Box 7	U_{20} = ... V to ... V in ... steps	range of rated ac no-load voltage and number of adjustable steps, or
	U_{2di} = ... V to ... V in ... steps	range of rated dc no-load voltage and number of adjustable steps, or
	U_{2d} = ... V to ... V en ... steps	range of rated dc no-load voltage and number of adjustable steps in case of inverter type welding equipment
Box 8	I_{2cc} = ... A	maximum short circuit current of the output corresponding to the minimum impendance (l and e minimum))
Box 9	I_{2cc} = ... A	maximum short circuit current of the output corresponding to the maximum impendance (l and e maximum)
Box 10	I_{2p} = ... A	permanent output current

16.3.4 Mains supply

Box 11	... ~ ... Hz	number of phases, e.g. 1 or 3, symbol for alternating current (~) and the rated frequency, e.g. 50 Hz or 60 Hz
Box 12	U_{1N} = ... V	rated supply voltage
Box 13	S_p = ... kVA	permanent power (duty factor 100 %)
	S_{50} = ... kVA	power at 50 % duty factor

NOTE $S_{50} = S_p\sqrt{2}$ will only be given for a transition period.

16.3.5 Other characteristics

Box 14	e	= ... mm to ... mm	range of the throat gap	
Box 15	l	= ... mm to ... mm	range of the throat depth	
Box 16	F_{max}	= ... N	range of maximum electrode force corresponding to the minimum and maximum throat depth	
Box 17	F_{min}	= ... N	minimum electrode force	
Box 18	F_{1max}	= ... N	maximum upsetting force	
Box 19	F_{1min}	= ... N	minimum upsetting force	
Box 20	F_{2max}	= ... N	maximum clamping force	
Box 21	F_{2min}	= ... N	minimum clamping force	

NOTE Boxes 18 to 21 are only applicable for butt welding equipment

Box 22	p_1	= ... bar	supply pressure of the energizing medium	
Box 23	p_2	= ... bar	pressure of the energizing medium to obtain maximum forces	
Box 24	Q	= ... l/min	rated cooling liquid flow	
Box 25	Δp	= ... bar	rated cooling liquid pressure drop	
Box 26	Mass	= ... kg	mass of the welding equipment	
Box 27	v	=... m/min to ... m/min	range of tangential speed or	
	n	=... min^{-1} to ... min^{-1}	range of speed of rotation	

NOTE Box 27 is only applicable for seam welding equipment.

Box 28	α_{10} =... mrad	deflection at	10 % of F_{max} or F_{1max}
	α_{50} =... mrad	deflection at	50 % of F_{max} or F_{1max}

NOTE These values are given only by agreement between manufacturer and purchaser.

	α_{100} =... mrad	deflection at	100 % of F_{max} or F_{1max}
Box 29	g_{10} =... mm	eccentricity at	10 % of F_{max} or F_{1max}
	g_{50} =... mm	eccentricity at	50 % of F_{max} or F_{1max}
	g_{100} =... mm	eccentricity at	100 % of F_{max} or F_{1max}

NOTE 1 These values are given only by agreement between manufacturer and purchaser.

NOTE 2 The eccentricity g is not applicable for butt welding equipment.

16.4 Tolerances

The actual values obtained from resistance welding equipment shall meet the rated values within the tolerances given in the corresponding subclauses.

Compliance shall be checked by measurement and comparision.

17 Instruction manual

All welding equipment shall be delivered with an instruction manual which shall include the following information:

a) general description;

b) correct methods of handling e.g. by fork lift or crane and precautions to be taken;

c) the meaning of indications, markings and graphical symbols;

d) supply connections including fuse and/or circuit breaker rating;

e) correct operational use relating to the resistance welding equipment (e.g. cooling requirements, location, control device, indicators);

f) welding capability, mechanical characteristics, limitations of duty and explanation of thermal protection if relevant;

g) limitations of use;

h) basic guidelines regarding protection against personal hazards for operators and persons in the work area (e.g. fumes, noise, hot metal and sparks);

i) maintenance;

j) adequate circuit diagram together with a list of essential parts;

k) information for the circuit of resistance welding equipment designed to supply electrical power at normal supply voltage (for example for lighting or electric tools);

l) installation and mounting.

Other usefull information may be given (e.g. class of insulation, deflection α, eccentricity g, maximum time per impulse t_i, power factor etc.).

Compliance shall be checked by reading the instruction manual.

Annex A
(normative)

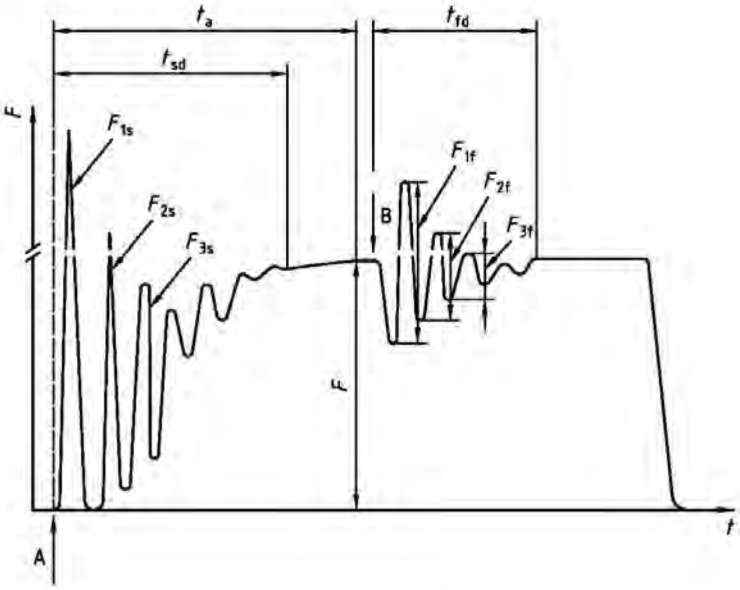
Dynamic mechanical behaviour

A.1 General

In recent years results of investigations on the dynamic mechanical behaviour of resistance welding equipment have become available. In order to create a common basis for discussion in the international engineering community, the new technical terms and the experimental method for measuring these characteristics are given in this annex.

A.2 Dynamic mechanical characteristics

Dynamic mechanical characteristics define the manner in which spot, projection, or seam welding equipment oscillate when electrode contact and follow-up occurs with the component to be welded (see Figure A.1).



A start of electrode contact   B start of electrode follow up

Figure A.1 — Dynamic behaviour of a spot welding equipment (schematic)

The measuring procedure is described in A.3.

The dynamic mechanical characteristics of butt welding equipment cannot yet be described due to lack of sufficient knowledge.

A.2.1 Electrode contact

Electrode contact with the component to be welded is represented by means of point A in Figure A.1. Electrode force ascent starts at this point up to the static electrode force F.

A.2.2 Electrode force oscillations after electrode contact

Force oscillations may occur after contact of the moving electrodes. The intensity and duration of force oscillation are measured and recorded by means of a force transducer located between electrode and welding head (see Figure A.2).

A.2.3 Bounce

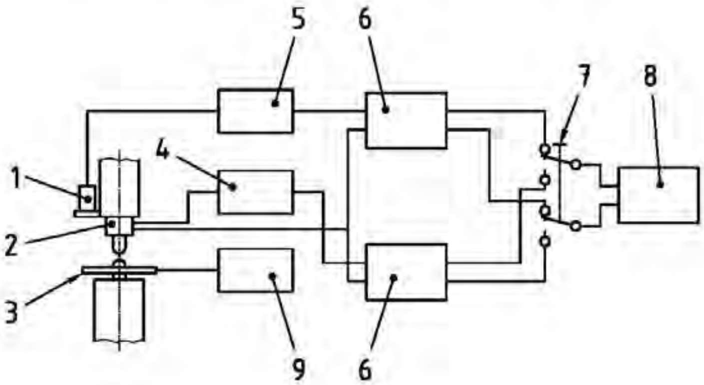
Electrode bounce may occur after electrode impact during which the electrode, due to the extremely high degree of oscillation in the welding equipment, may even lose contact with the component to be welded (see A.2.6.2).

A.2.4 Follow-up

Follow-up of the welding equipment, which starts as of point B in Figure A.1, occurs during expanding and contracting of the material while heating and cooling, due to indentation of the electrodes into the component or when projection collapse occurs.

A.2.5 Force oscillations during follow-up

Force oscillations may occur during follow-up. The intensity and duration of the oscillations are measured and recorded by means of a force transducer located between electrode and welding head (see Figure A.2).



Key

1 Oscillation speed sensor
2 Force and current measuring head
3 Rogowsky belt
4 Charge amplifier
5 Frequency response equalizer
6 Digital store oscilloscope
7 Switch
8 x–y writer
9 Impulse circuit measurer

Figure A.2 — Determination of dynamic mechanical characteristics (schematic example)

A.2.6 Characteristic quantities

A.2.6.1 Impact velocity (v_a)

Impact velocity v_a is the velocity of the moving electrode or platen immediately prior to contacting the component to be welded.

A.2.6.2 Impact energy (E_a)

Impact energy E_a is the kinetic energy of the moving mass of the welding head, electrode holder, electrode and a portion of the flexible conductors and/or jumpers just before electrode contact with the component. It is calculated from the moving mass m and the impact velocity v_a according to the following formula:

$$E_a = \frac{m(v_a)^2}{2}$$

A.2.6.3 Coefficients of force (K_F, K_{Fs} and K_{Ff})

Coefficient of force K_F describes the decay of the force amplitude during electrode contact or follow up (See Figure A.1).

$$K_F = \frac{F_1 + F_2 + F_3}{3F}$$

NOTE 1 Coefficient K_F and forces F_1, F_2 and F_3 are written with index s to indicate electrode contact.

NOTE 2 Coefficient K_F and forces F_1, F_2 and F_3 are written with index f to indicate follow-up.

NOTE 3 Forces F_1, F_2 and F_3 are the first three complete oscillations upon electrode contact or follow-up.

A.2.6.4 Force rise time (t_a)

Force rise time t_a is the time span from initial contact of the electrodes up to the point when the nominal static electrode force has been reached (see Figure A.1).

A.2.6.5 Decay time (t_{sd}, t_{fd})

Decay time t_{sd} or t_{fd} of the force oscillations resulting from the electrode contact or follow-up process can be determined by means of Figure A.1.

A.3 Measuring procedures for determination of dynamic mechanical characteristics

A.3.1 General

In order to assess the dynamic mechanical characteristics, impact energy E_a and the time sequence of the electrode force during contact and follow-up need to be determined.

A.3.2 Calculation of impact energy

The impact velocity v_a required for calculation of the impact energy E_a (see A.2.6.2) can be obtained either from the displacement-time curve of the moving electrode or, by means of a sensor measuring the oscillation velocity (frequency range: approximately 10 Hz to 1 kHz). The operational stroke of the electrode shall be 5 mm.

The moving mass of the force generation system including pistons, piston rod, platen, electrode holder, electrode and a portion of the flexible conductors and/or jumpers can either be obtained from information furnished by the manufacturer, by calculation or by weighing.

An example of such a measuring system is shown in Figure A.2 as a block circuit diagram. The impact velocity v_a can be obtained from the oscillation velocity sensor signals.

A.3.3 Calculation of force oscillations during electrode contact and follow up

For measurement of the force-time curve, a force sensor shall be located in the welding head as close as possible to the electrode. The force transducer shall have a frequency of 0 Hz to at least 3 kHz, e.g. a piezo-quartz type, and the output displayed against a time base on an oscilloscope (see Figure A.2). Evaluation of the force amplitudes shall be carried out in accordance with A.2.6.3.

The follow-up behaviour is determined by means of a simulation test. In this test, a circular projection in accordance with ISO 8167, stamped into a steel sheet is rapidly melted away by using a sufficiently high current impulse (t = 1 period) above the splash limit. The follow-up of the electrode is determined by measuring the height of the projection weld after application of the electrode force. Evaluation of the force amplitudes is carried out in accordance with A.2.6.3.

Based on the contact fault measurements, the measured values shall be determined in accordance with clause 15 for 10 %, 50 %, and 100 % of the maximum electrode force.

Annex B
(informative)

Examples for rating plates

a)	Identification		
	1) Manufacturer, country		Trademark
	2) Resistance seam welding equipment		
	4) Serial number Year of production	5) ISO 669	
b)	Welding output		
	6) ~	7) U_{20} = 4 V to 8 V in 4 steps	
	8) I_{2cc} = 45 kA	9) I_{2cc} = 30 kA	10) I_{2p} = 22 kA
c)	Mains supply		
	11) 1 ~ 50 Hz	12) U_{1N} = 400 V	
	13) S_P = 176 kVA	(S_{50} = 250 kVA)	
d)	Other characteristics		
	14) e = 215 mm	15) l = 550 mm	
	16) F_{max} = 1 200 daN	17) F_{min} = 200 daN	
	22) p_1 = 8 bar	23) p_2 = 6 bar	
	24) Q = 16 l/min	25) Δp = 2 bar	
	26) Mass = 1 350 kg	27) v = 0,8 m/min to 8,0 m/min	
	28) α_{10} = mrad α_{50} = 0,05 mrad α_{100} = 0,24 mrad	29) g_{10} = mm g_{50} = 0,015 mm g_{100} = 0,02 mm	

Figure B.1 — Seam welding equipment

a)	Identification		
	1) Manufacturer, country		Trademark
	2) Resistance spot welding equipment		
	4) Serial number Year of production	5) ISO 669	
b)	Welding output		
	6) ~	7) U_{20} = 3,5 V to 7,0 V in 4 steps	
	8) I_{2cc} = 21 kA	9) I_{2cc} = 15 kA	10) I_{2p} = 7,8 kA
c)	Mains supply		
	11) 1 ~ 50 Hz	12) U_{1N} = 400 V	
	13) S_P = 56 kVA	(S_{50} = 80 kVA)	
d)	Other characteristics		
	14) e = 115 mm to 415 mm	15) l = 1 050 mm	
	16) F_{max} = 600 daN	17) F_{min} = 100 daN	
	22) p_1 = 8 bar	23) p_2 = 6 bar	
	24) Q = 12 l/min	25) Δp = 2 bar	
	26) Mass = 560 kg		

Figure B.2 — Spot welding equipment
(if indication of deflection α and eccentricity g has not been agreed)

a)	Identification		
	[1] Manufacturer, country		Trademark
	[2] Resistance projection welding equipment		
	[4] Serial number Year	[5] ISO 669	
b)	Welding output		
	[6] ⎓	[7] U_{2di} = 11 V	
	[8] I_{2cc} = 165 kA	[9] I_{2cc} = 130 kA	[10] I_{2p} = 22,5 kA
c)	Mains supply		
	[11] 3 ~ 50 Hz	[12] U_{1N} = 400 V	
	[13] S_p = 212 kVA	(S_{50} = 300 kVA)	
d)	Other characteristics		
	[14] e = 200 mm to 500 mm	[15] l = 350 mm	
	[16] F_{max} = 3000 daN	[17] F_{min} = 230 daN	
	[22] p_1 = 8 bar	[23] p_2 = 6 bar	
	[24] Q = 38 l/min	[25] Δp = 4 bar	
	[26] Mass = 2 230 kg		

Figure B.3 — Projection welding equipment
(if indication of deflection α and eccentricity g has not been agreed)

a)	Identification		
	[1] Manufacturer, country		Trademark
	[2] Resistance butt welding equipment		
	[4] Serial number Year of production	[5] ISO 669	
b)	Welding output		
	[6] ⎓	[7] U_{2di} = 11 V	
	[8] I_{2cc} = 220 kA	[9] I_{2cc} = 200 kA	[10] I_{2p} = 53,4 kA
c)	Mains supply		
	[11] 3 ~ 50 Hz	[12] U_{1N} = 400 V	
	[13] S_p = 410 k VA	(S_{50} = 580 kVA)	
d)	Other characteristics		
	[14] e = 135 mm to 180 mm	[15] l = 450 mm	
	[16] F_{max} = 1 000 kN	[17] F_{min} = 300 kN	
	[18] F_{1max} = 1 000 kN	[19] F_{1min} = 500 kN	
	[20] F_{2max} = 2 000 kN	[21] F_{2min} = 1 000 kN	
	[22] p_1 = 140 bar	[23] p_2 = 130 bar	
	[24] Q = 150 l/min	[25] Δp = 6 bar	
	[26] Mass = 26 000 kg		

Figure B.4 — Butt welding equipment

ICS 25.160.30
Price based on 38 pages

D-2. Metal Work

D-2-1. Failure Equipment List (Conventional Turning Machine)

GOVERNMENT INDUSTRIAL TRAINING INSTITUTE (NORTH), CHENNAI - 600 021

ACTION PLAN

TRADE :________________________________ UNIT : ____SHIFT : ____

NAME OF THE INSTRUCTOR WITH DESIGNATION : ____

SL. NO	NAME OF THE MACHINE / EQUIPMENTS	FAULTS NOTICED	REASON FOR REPAIRS	DATE ON REPAIRS	ACTION PLAN				INITIAL OF JTO / ATO	INITIAL OF TO	INITIAL OF DD / PRL
					TARGET DATE TO COMPLETE	REPLCEMENT OF PARTS	APPROX. COST	RECTIFI CATION BY			

D-2-2. Progress Management Sheet for Equipment Environment Maintenance Planning (ITI Mint)

Dated: 19/08/2016

TOT Turning Section: Improvement of Equipment and Training Environment (To be resolved by end-October 2016)

No.	Name	Current state(Aug 16)	Expected date of completion 16 (?) machines (DD/MM/YYYY)	Completed date for 16 (?) machines (DD/MM/YYYY)
1	Inspection sheet	11 machines	09-09-2016	
2	Operation sheet/Drawing stand	2 machine	31-10-2016	
3	Work table	1 sample to be prepared by 24th August (Friday)	24-08-2016	
4	Chuck key	1 sample to be prepared by 22nd August (Monday)	31-08-2016	
5	Lighting/fan	Each instructor will submit necessary lighting requirement for his/her unit to the DD	24-08-2016	
	Fixing of light/fan	-	To be decided by DD	
6	Gear indication mark (arrow mark)	To be marked (painted) on the remaining machines	09-09-2016	
7, 8	Feed handle grips	There are several handles without grip, and operation is difficult	24/08/2016	
		Each instructor will submit necessary handle/grip requirement for his/ her unit to the DD		
	Fixing of handle grip	-	To be decided by DD	
9	Tool centre height adjustment jig.	1 sample stand to be prepared	One sample: 31/10/2016	

D/D: Signature — D. Prabakar

Training officer Signature — D Gunasekaran

Trainer name & Signature — T. Sumathi, D. Basil, P Mary Merija, D Johendran, S. Chezhian, D Vijayan, M Srinivasan, D. Selvi, P. Logu

Inspection sheet

Operation sheet/
Drawing stand

Work table

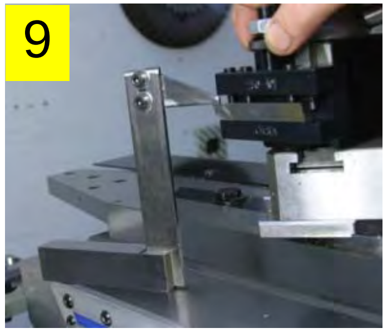
Chuck handle

Lighting

Gear indication mark (arrow mark)

Feed handle grip

Feed handle grip



Tool centre height adjustment jig

Dated: 26/08/2016

PILOT MONITORING IN NOVEMBER 2016

S No.	Content	In-charge	Planned	Monitoring activity
1	Drill thinning operation	Ms. T. Sumathi	Training of all senior students in thinning operation	Monitoring of any 5 senior students
2	Center height jig	Mr. D Johendran	Fabrication of sample (Brass/SS) (Planned for 9 units)	Monitoring of any 5 senior students
3	Chuck key	Mr. D Basil	Fabrication of chuck key (Planned for 16 units) (Note: Each trainer should submit the drawing of check key/ keys of his or her unit	Monitoring of any 5 senior students
4	Pre-operation inspection sheet	All trainers & Mr. K. Gunasekaran (Coordinating training officer)	Prepare suitable inspection sheets according to the machine models in his or her unit and Training Officer will update the sheets accordingly	Monitoring of any 5 senior students
5	Drawing stand	All trainers	Drawing must be displayed on the stand. The trainer must give instructions to students while referring to the drawing when they are performing the operation	Monitoring of any 5 senior students
6	Management and handling of verniers	All trainers	Place the verniers properly and separately without mixing it along with other tools	Monitoring of any 5 senior students

D/D: Signature	D. Prabakar	Training officer Signature	D Gunasekaran

Trainer name & Signature	T. Sumathi	D. Basil	P Mary Merija	D Johendran	S. Chezhian	D Vijayan	M Srinivasan	D. Selvi	P. Logu

D-2-3. Progress Management Sheet for Equipment Environment Maintenance Planning (PCFCT)

Dated : 31/08/2016-2/09/2016

TOT Turning: Improvement of Equipment and Training Environment (To be resolved before enrollment of students)

No.	Name	Current state and countermeasure (Aug 31)	Expected date of completion	Expected date of completion
1	Grinder (2 nos.)	Hand rest is too low. To be adjusted at a higher level.	23-09-2016	Before October 10, 2017
2	Grinder (1 no.)	Light to be provided for the big grinder.	13-09-2016	
3	Grider (2 nos.)	No coolant. Coolant facility to be provided.	13-09-2016	
4	Fire extinguisher (2 nos.)	Fixing is unstable. Stand to be provided appropriately.	in progress	
5	Lathe machine (2 nos.)	rpm not visible. To be displayed.	in progress	
6	Shim (2 sets)	To be made available.	17-09-2016	
7	Display stand for operation sheet, etc.	To be made available.	17-09-2016	
8	Box spanner (2 nos.)	One is available, but height has to be reduced to half. 2 nos. to be made available.	13-09-2016	
9	Lathe machine operation drawings (practical training syllabus)	In progress. To be completed.	13-09-2016	
10	Theory test content	To be started. Include contents of 1. Machine Maintenance, 2. Pre-operation m/c inspection 3. Safety, 4. Process check sheet , 5. 5-S in the test paper	in progress	
11	Fan/light switchboard of workshop	Fan/light position and switch positions are random - waste of time in identifying the right switch for the respective fan/light. Layout diagram to be displayed beside the switchboard.	02-12-2016	
12	Tool arrangement on work table	There are tools that are not required for the operation. Placement of tools is not suitable -Waste of time. Placing of tools to be reviewed and changed	01-09-2016	
13	Placement of brush, chuck-key and box spanner	Placement of tools is not suitable. Make provision on m/c	23-09-2016	
14	Vernier	Quality is poor. To be replaced (2 nos.)	23-09-2016	
15	Maintenance record	Not used. To be prepared and used	in progress	
16	Shim	Shims are uneven. To be scrapped and good quality shims to be provided.	17-09-2016	
17	Cutting tool and shim	Cutting tool is being adjusted with shim. Bind the cutting tool and shim together as one unit and use. Shim to be purchased.	in progress	
18	Cutting tool edge	Tool edge is higher than the center. Adjust m/c tool post to match the center.	in progress	
19	Chamfering processs	File is being used. In training practical (Simple turning), use chamfering tool.	17-09-2016	
20	Chamfering tool	Not available. Fabricate using bevel protractor.	17-09-2016	
21	Center height jig	To be made available.	28-9-2016	

D-2-4. Self-study Material (PCFCT)

02/09/2016

TOT TURNING (Mr. Arul Thambi & Mr. Pavendhan)

THE FOLLOWING TO BE PRACTISED WELL BEFORE THE PILIT STUDY IN THE BEGINNING OF NOVEMBER.

Simple turning:

1. Saddle feed: Mark final depth point.
2. Saddle feed is auto mode.
4. Dimension checking with Vernier: On the m/c.
5. No. of passes: To be discussed.
6. Roughing operation: Steel rule. Finishing : Vernier.
7. After operation: Remove cutting too, clean chips, wipe the m/c fully.
8. Remove chips in the order of top to bottom.

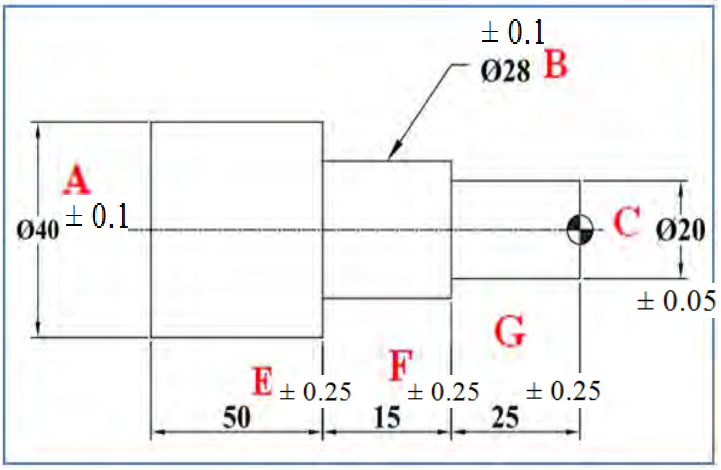
D-2-5. Example of Student Assessment Sheet (PCFCT)

Student Assessment Sheet

Student Name: **Commenced on: 02.04.2016**

Ex. No.: **Completed on: 04.04.2016**

Step Turning Operation



Dimensional Accuracy

A = Dia. 40

B = Dia. 28

C = Dia. 20

E = L 50

F = L 15

G = L 25

A to G Each carries 5 Marks

Used Material: MS (Ø28 x L80)

All Dimensions are in mm

Special Features

X = Sequence of operations

Y = Turning operation

Z = Overall finishing operation

5S – Housekeeping

1 = Document Maintenance

2 – Pre machining maintenance

3 – Post machining maintenance

Sl. No	Dimensional Accuracy						Total 30	Special Features			Total 30	5S -House Keeping			Total 40	G. Total 100
	A	B	C	E	F	G		X	Y	Z		1	2	3		
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																

Trainer **Centre Head**

D-2-6. Pre-operation Inspection Sheet (Conventional Turning Machine)

2016/2/5

Month Year Conventional Lathe Chart of Pre-Operation Inspection

Sheet No.

Machine name	Esteem
Machine no.	
Installation location	
Person responsible	

Must be submitted by the 5th of the following month
Instructor --> Training officer --> DD / Principal

Training officer	Instructor

		No.	Inspection item	criteria	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Daily	Before starting operation	1	Dirt on floor /machine surface or cover	No chips																															
		2	Cleanliness of chip box	No chips																															
		3	Oiling of sliding surfaces	As needed																															
		4	Oiling of tool post, feed support, tailstock	As needed																															
		5	Chuck tightness	Must not be loose																															
		6	Safety guard Close	Must be closed																															
		7	3-phase power switch ON	3 phases Light ON																															
		8	Main power switch ON	Should be ON																															
		9	Starter switch ON	Should be ON																															
		10	Forward/reverse lever ON	Forward lever ON																															
Weekly	Oil level check	1	a. Main gear box	As needed																															
			b. Feed gear box	As needed																															
			c. Carriage box	As needed																															
	Belt check	2	Damage or looseness	Should not be damaged or loose																															
	Lubrication check	3	a. Head stock	As needed																															
			b. Cross-slide	As needed																															
			c. Compound slide	As needed																															
			d. Tail stock	As needed																															
			e. Lead screw	As needed																															
			f. Feed shaft	As needed																															
	Coolant Tank check	4	a. Coolant draining and tank cleaning	Visual check																															
			b. Replacement of coolant	Visual check																															

		No.	Inspection item	criteria	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Monthly	Machine cleaning	1	Chuck cleaning	Dismantle and full cleaning																															
		2	Cross-slide cleaning	Dismantle and full cleaning																															
		3	Compound slide cleaning	Dismantle and full cleaning																															
		4	Tail stock cleaning and oiling	As needed																															
		5	Line cables	Visual check																															
Annual	Electrical check	1	Check spindle main motor	As needed																															
		2	Check coolant motor	As needed																															
		3	Tightness of m/c Allen screws, hexagonal bolts and nuts	All must be tightened																															
Name of person conducting inspection at operation start																																			
Notes			Describe the machine history and any problems that occurred. No problem: ✔ There is problem : X If any problems are found, please contact your instructor immediately.																																	

D-2-7. Pre-operation Inspection Sheet (CNC Turning Machine)

2016/2/5

20 (year) (month) NC Lathe Chart of Pre-Operation Inspection

Sheet No.

Equipment name	NC Lathe (QTN)
Equipment no.	
Installation location	
Person responsible	

Must be submitted by the 5th of the following month by the person in charge of prototype in machining technology section
Person in charge --> N --> Safety supervisor --> C

Section manager	Safety supervisor	Squad leader	Person in charge

		Inspection item	Safety criteria	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Inspection at start of operation	1.	Dirtiness of main body, floor surface, surrounding area	Visual check (no oil leaks, etc.)																															
	2.	Oil level of NC lathe and B/F (cutting, lubrication, operation, cooling)	Within the indicator range, refill as needed																															
	3.	Mist collector drain hose liquid seal (tap water)	Visual check, refill as needed																															
	4.	Cleaning of chips in chip pan and inside machine	Removal of chips																															
Nighttime unmanned operation inspection	5.	Program	Program check																															
	6.	Coolant level and lubricant level	Within indicator range																															
	7.	Automatic power shutoff	Switch check																															
	8.	Fire extinguisher power and nozzle angle	Visual check																															
	9.	Nighttime unmanned operation indicator lamp	Turned on																															
	10.	Compressor timer setting	Timer check																															
Weekly	11.	Inspection of coolant tank filter （weekly)	Visual check/Cleaning																															
	12.	Oiling of chuck (weekly)	Required amount																															
	13.	Check of tailstock operation, cleaning of chips in surrounding area (weekly)	Operates smoothly																															
	14.	B/F air drain (weekly)	No moisture																															
	15.	Dust collector filter shaking (weekly)	Pull lever (4 to 5 times)																															

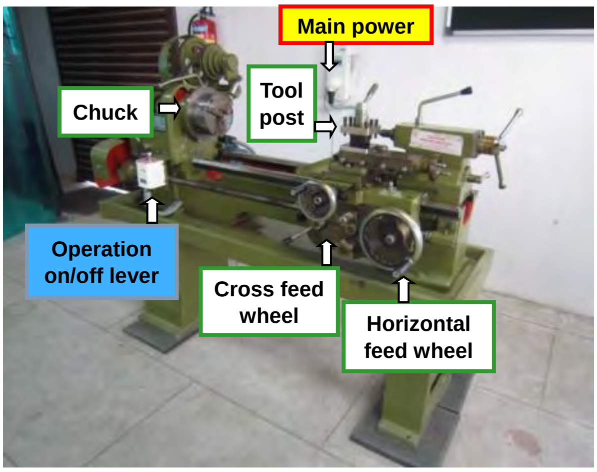
		Inspection item	Safety criteria	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Monthly	16.	B/F oil filter inspection (monthly)	Visual check/ Cleaning																															
	17.	Two emergency stop locations (NC lathe, B/F) (monthly)	Operation check																															
	18.	Door/cover interlock (including B/F) (monthly)	Operation check																															
	19.	Concentration of coolant (monthly)	5% to 20%																															
	20.	Cleaning of dust collector filter and disposal of chips (monthly)	Visual check/ Cleaning/ Replacement																															
Every 6 months	21.	Inspection of mist collector filter (June and December)	Visual check/ Cleaning/ Replacement																															
	22.	Replacement of coolant and cleaning of tank (June and December)	Visual check/ Cleaning/ Replacement																															
Annual	23.	Cleaning of control panel filter (December)	Visual check/ Cleaning/ Replacement																															
	24.	Changing of B/F hydraulic oil (December)	Visual check/ Replacement																															
Name of person conducting inspection at operation start																																		
Supervisor approval (weekly)																																		
Notes	Describe the machine history and any problems that occurred. No problems: ✔ If any problems are found, please contact your supervisor immediately.																																	

D-2-8. Safety Guidelines (PCFCT)

Safety Work Guidelines	Created by	A. Arulthambi	Revision	A				
	Inspected by	Dohro						
Lathe Workshop		Mechanical equipment	Lathe work operations	Description of work		Turning processes		

Designated assignment	
Prohibited items	1. Do not bring fingers or hands near while rotating.
	2. Do not touch chips with your bare hands.
	3. Do not use waste cloth for wiping while rotating
Prohibited protective equipment	1. Gloves
	2. Loose clothing
Hand tools used	1. Socket spanner
	2. Hammer
	3. Double end spanner
	4. Allen key
	5. Chuck key
	6. Cleaning brush
Protective equipment used	1. Safety goggles
	2. Safety shoes
	3. Apron
When problem occurs	1. Turn off the machine switch and switch off main power
	2. Contact the supervisor, and request Maintenance to perform repair.

Simplified Diagram



No.	Work procedure	Key points
1	Before starting work operations (1) Pre-operation inspection check points	- If any problems are found, contact the supervisor. - Check that the machine stops within 1 second and check for unusual sounds.
2	Work operation (1) Setting of rotational speed (2) Tighten the work piece onto the chuck. (3) Mount the cutting tool (4) Turn on the machine power switch. (5) Start spindle rotation. (6) Use the handle to perform cutting according to the machining drawing. (7) Spindle stop (8) Check the dimensions.	- Be sure to always turn off the main power whenever changing the gear or chuck or making shifting adjustments.
3	After work operations are completed (1) After completion, turn off the machine switch. (2) Take out the cutting tool and work piece. (3) Clean the machine and surrounding area	- Take care when handling the cutting tool. - Use brush & burr collecting tray to remove chips.

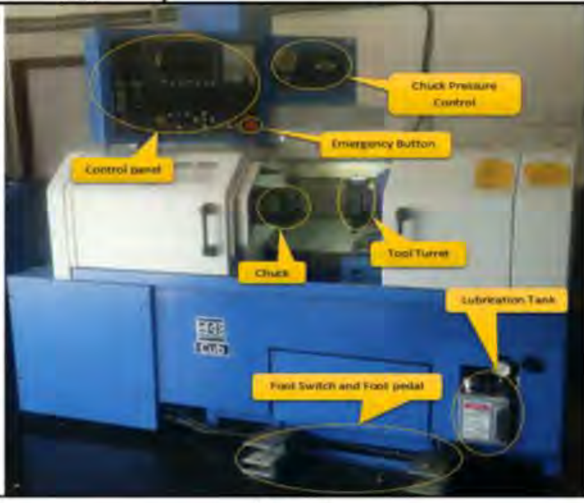
Work Guidelines		

D-2-9. Safety Guidelines (AIEMA)

CNC: Attention for operators

1. Only one operator should be operate machine at a time.
2. Take special care when changing the tool.
3. Do not insert any material while spindle is rotating.
4. Keep the door closed while the machine is running.
5. Do not open the control panel before switch OFF the power.
6. Do not place any object on the control panel.
7. After the machining process, check whether the dimensions as per required sizes.
8. Check the coolant oil and lubrication oil as per level.
9. If there is any accident in the machine, immediately push the emergency / reset button.
10. Keep your workplace with neat and clean.
11. Before cleaning the chips you have to wear the gloves.
12. During the machine running the operator should stand in front of the machine.
13. Keep required tools and equipment near by the machine.

D-2-10. Operation Sheet (CNC Turning Machine, AIEMA)

<table>
<tr><td rowspan="2">Operation Guidelines</td><td>Created by</td><td colspan="2"></td><td rowspan="2">Revision</td><td rowspan="2">A</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Inspected by</td><td colspan="2"></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Centre name</td><td>AIEMA</td><td>Mechanical equipment</td><td>CNC Lathe</td><td colspan="2">Description of work</td><td colspan="5">Cutting processes</td></tr>
<tr><td rowspan="2">Prohibited items</td><td colspan="3">1 Objects on the machine</td><td colspan="7" rowspan="12">
</td></tr>
<tr><td colspan="3">2 Machining while coolant and air are OFF</td></tr>
<tr><td>Prohibited protective equipment</td><td colspan="3">1 Gloves</td></tr>
<tr><td rowspan="3">Hand tools used</td><td colspan="3">1 Align key set</td></tr>
<tr><td colspan="3">2. Spanners</td></tr>
<tr><td colspan="3">3. Measuring instruments</td></tr>
<tr><td rowspan="2">Protective equipment used</td><td colspan="3">1 Safety shoes</td></tr>
<tr><td colspan="3">2 Leather gloves (when cleaning chips only)</td></tr>
<tr><td rowspan="3">When problem occurs</td><td colspan="3">1 Press the emergency stop button, and turn off the main power.</td></tr>
<tr><td colspan="3">2 Press reset button</td></tr>
<tr><td colspan="3">3 Contact the supervisor.</td></tr>
</table>

No.	Work procedure	Key points
1	Turn on the main power.	
2	Turn on control panel power.	- Perform pre-operation inspection.
3	Release the emergency stop button	
4	Origin return (X and Z-axis)	- Origin return: X and Z near origin
4	From machining Program creation and input (dialog program, G codes, M codes)	- Program creation using control panel - When creating a program, the proper material protrusion length and cutting conditions are set.
5	Selection and setup of cutting tool	- When loading and removing the tool holder and cutting tool, be careful that your hand does not slip and result in an injury. - Make the proper settings for the tool length and cutting edge position (be sure to carefully observe the maximum protrusion length). - If the above settings have not been made, be particularly careful when turning the turret. - A maximum of 8 tools can be loaded (avoid using turrets adjacent to the sensor as much as possible).
6	Selection and setup of various workpiece materials (main unit and B/F) * Be sure to set the B/F from Enable to Disable at setup (operation panel).	- Be careful not to mistake the workpiece material type and the tool material diameter and length. - Select proper work holding devices to calm the pipe(example soft job with chuck) - For chuck workpiece using jaws.
7	Test (first product) machining - Short materials	- B/F and mist collector are set from Disable to Enable on the operation panel before starting machining. - Be sure to always activate the interlocks for the door and B/F cover. - Be sure to always use stoppers when feeding B/F materials (initial protrusion is machining length or less). - Check the various machining operations and cutting edge position in single block mode. - Perform rapid traverse of the first product at about 25% to 50% (interference check). *Be particularly careful when using a sensor. - Check the direction of the coolant nozzles for interference. - The workpiece is clamped securely when using a footswitch. - The cover must be closed when not using the footswitch. - After machining, check the dimensions
8	After machining is complete - Remove the workpiece	
	- Clean the machine	- Use compressor air - Use rust prevention oil
9	- Control panel power OFF - Main power OFF on side of machine	- Perform dimensional check

D-2-11. Work Procedure Sheet (CNC Turning Machine, AIEMA)

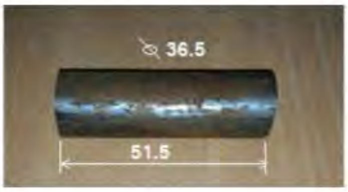
WORK PROCEDURE SHEET

Work	Series of CNC work by soft jaw machining	Machine	ACE Designers/Cub
Model	IGLOO	Product Name	Taper Turning
Safety	1. Use of work gloves is prohibited (wear work gloves only when changing the soft jaw). 2. Firmly tighten the chuck jaw with hexagonal bolts and confirm.	Measuring device	Vernier Calipers (0 – 150mm) Micrometer (25 - 50mm)
		Tools	Hexagonal wrench, Soft jaw, roughing Tool, Finishing Tool, Hexagonal bolt

<Used equipment>

CNC MACHINE

<Used Material>



MS

<Used measuring devices and tools>

Soft jaw

Hexagonal bolt

Hexagonal wrench

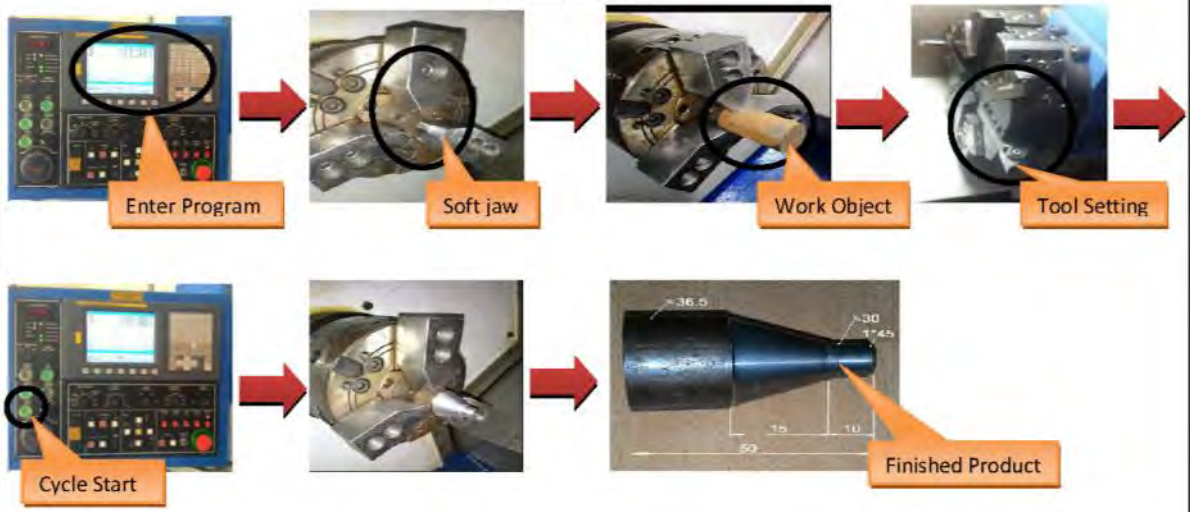
Vernier caliper

Micrometer

PCLNL- CNMG

MTJNL- TNMG

<Work procedure>



NO	Work Procedure	Work Key Points and Caution
	<Production preparation> Confirm the materials as designated on the drawing. Prepare the measuring devices and tools to be used	Use Steel rod of around Ø36.5x51.5. Rotation speed S1500 Feed F0.15
1	**<Start of Work>** Mount the Work piece and perform the process.	1. Process the outer diameter with a PCLNL- CNMG. 2. Process the Taper Turning 3. Process with the MTJNL- TNMG. *After processing, check the dimensions with caliper & Micrometer.
2	Work procedure of CNC Machine.	1. Enter program in the machine. 2. Wear work gloves when attaching the soft jaw. 3. Confirm that hexagonal bolt is firmly tightened. 4. Rotate the soft jaw chuck. (Trial operation at low speed) 5. Clamp the work piece. 1. Chuck the dummy round bar. 2. Set the appropriate chuck pressure according to the dimension of the work piece. For continued processing. Speed at S2000rpm, Feed at F0 .1 6. Set the Tool. 1. One by one set the Tools. (PCLNL- CNMG and MTJNL- TNMG) 2. Offset setting. 7. Cycle Start.
3	Chuck the work piece.	*Confirm that the work piece is firmly chucked.
4	Process the work piece.	Roughing Process PCLNL-CNMG (Speed at 1500RPM, Feed at 0.15mm/rev Each Pass- 2.0mm) Finishing Process MTJNL-TNMG (Speed at 2000 RPM, Feed at 0.1mm/rev One Pass-0.5mm)
5	<End of work> Remove the work piece.	Remove any cutting powder from the work piece by air and complete.
6	Cleaning – up.	After completion of work, clean the machine using waste cloth and air.

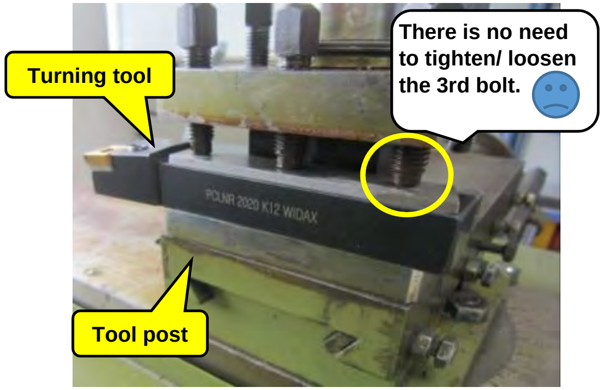
Prepared									
checked									

D-2-12. Kaizen Sheet Sample 1

Improvement by reducing the working time at the lathe tool post (For step turning)

Prepared on: 10/12/2016
Prepared by: Masato Dohro, Kunimori Ogiyama
Interpreter: Parameswari

Before improvement



After improvement

Reason for improvement	Effect of improvement
Prior to the improvement, time was spent on tightening and loosening the 3rd bolt of the tool post, which was not necessary.	After the improvement, by not tightening /loosening the bolt (1 bolt) of the tool post, which is not necessary, it is possible to reduce about 96 working hours in a year. Tightening/ Loosening time of 1 bolt → Approx. 1 minute ● The number of settings (turning + chamfering tool) that would be conducted by one student in a single day is two. The reduced working time per day would be 2 (minutes / person) ● For 4 students, the working time would be reduced by 8 (minutes / person) in a day. ● As there are 2 lathe units, it would be 8 (minutes / person) x 2 (units) = 16 minutes in one day ● Approx. 16 (minutes / day) x 30 (days) = Approx. 8 (hours / month) ● 8 (hours/month) x12 (month) = Approx. 96 (hours/year)

D-2-13. Kaizen Sheet Sample 2

Improvement by time reduction with work table storage (For step turning)

Prepared on: 10/12/2016
Prepared by: Masato Dohro, Kunimori Ogiyama
Interpreter: Parameswari

Before improvement

After improvement

Reason for improvement

Prior to improvement, the time spent for setting + step turning of lathe (1 unit) was more than about 35 minutes.
<u>Setting (Approx. 15 minutes) + Step turning (Approx.20 minutes) = **Approx. 35 minutes / operation**</u>

- 3(Times per day/unit)× Approx.35(Minutes each time)× 2(No. of lathe units)= Approx. 210 (Minutes/day)= Approx. 3.5 (Hours/day)
- Approx. 3.5 (Hours/day) × 30 (Days)=Approx. 105 (Hours/ month) =Approx. 1,260 (Hours/year)

<Primary reason for improvement>

1. Tools / measuring instruments, which are not required for the work are placed on the work table.
   a. Long scale
   b. File
   c. Hammer d. Scriber
2. There is no place to arrange tools / measuring instruments, and work piece, which is necessary for the work.
   a. Turning tool
   b. Chamfering tool
   c. Micrometer(0~25mm) d. Work piece
3. Since the Vernier is stored in the box, time was spent in taking it out.
4. Since the respective shims of the turning tool and chamfering tool were removed each time, time was spent in adjusting the thickness of the shim while fixing the turning tool.
5. Since the respective shims of the turning tool and chamfering tool were removed each time, and time was being spent in taking and returning the shims from the tool shelf to the work table, and in searching for the appropriate thickness of the shim to be used.
6. Time was spent in the operation, as a location could not be ensured in the front on the work table, for measuring instruments that are frequently used.

Effect of improvement

After improvement, the working time of lathe (1unit) setting + step turning was shortened by about 15minutes, and **it would be possible to reduce the operation time of by 540 hours in one year.**
<u>Setting time + step turning (Approx. 20 minutes) = **Approx. 20 minutes / operation**</u>

- 3(Times per day/unit)× Approx. 20 (Minutes each time) × 2(No. of lathes)= Approx.120 (Minutes/day)= Approx.2 (Hours/day)
- Approx. 2(Hours/day)× 30(Days)= Approx. 60 (Hours/month)=(Approx.720 hours/year)
- Approx. 1,260 (Hours/year) before improvement - 720 (Hours/year) after improvement = Approx. 540 (Hours/year)

<Primary effect of improvement>

1. By clearing the tools and measuring instruments that are not required for the operation, it is possible to reduce the time spent and wasted in securing / searching for the location on the work table.
2. By securing a location for placing tools and measuring instruments necessary for the operation on the work table, it is possible to reduce the time spent in taking out the turning tool, chamfering tool, micrometer, work piece, etc. from the storage location.
3. By removing the Vernier out of the box and placing it on the work table, it was possible to reduce the working time.
4. The work of adjusting the thickness of the shims has been reduced by keeping the respective shims along with the turning tool and chamfering tool even after the completion of the turning operation.
5. Since the respective shims of the turning tool and the chamfering tool are kept together even after completion of the operation, it is possible to reduce the time spent in taking out/ keeping back the shims, and the time spent in searching for the thickness of the shims to be used.
6. With the fixing of storage place for brush, chuck handle, and box wrench on the lathe, and moving of the frequently used measuring instruments/turning tool and chamfering tool towards the front on the work table, it was possible to reduce the working time.

D-2-14. Sheet for Practical Turning Training

1) Diamond cutters retain hardness upto…

(a) 10000 (b) 12500C
(c) 13500C (d) 16500C

2) What is CBN?

(a) Carbon Boron Nitrade
(b) Carbon Body Nitrade
(c) Cubic Boron Nitrade
(d) Cubic Box Nitrade

3) Cemented carbides retains red hardness upto

(a) 10000C (b) 8000C
(c) 15000C (d) 9000C

4) The shape of TNMG insert tool is

(a) Triangle (b) Round
(c) Square (d) Rectangle

5) The device that is used for supporting the work piece when work surfaces are to be milled at right angles to another surface

(a) V-bolt (b) V-block
(c) Vice (d) Angle plate

6) The part of the milling machine which is used as an extension of machine spindle on which milling cutters securely mounted is

(a) Over hanging arm (b) Arbor
(c) Knee (d) Column

7) High speed steel milling cutters retains hardness upto

(a) 9000C (b) 10000C
(c) 15000C (d) 8000C

8) An optical rotary encoder converts the rotary motion into

(a) Sequence of Digital pulse (b) Linear motion
(c) Light signals (d) Sound signals

9) The least count of an vernier height gauge is

(a) 0.02mm (b) 0.1mm
(c) 0.05mm (d) 0.001mm

10) The type of indexing used to carry out compound indexing in automatic way is

(a) Simple indexing (b) Compound indexing
(c) Differential indexing (d) Angular indexing

11) What is the G code for tool nose compensation right in FANUC system

(a) G03 (b) G04
(c) G41 (d) G42

12) The cutting speed of diamond tools are about

(a) 25 times greater than HSS
(b) 30 times greater than HSS
(c) 50 times greater than HSS
(d) 20 times greater than HSS

13) Magnetic chuck is for holding

(a) Copper work piece (b) Steel work piece
(c) aluminium work piece (d) Brass work piece

14) For rough milling the rate of feed of tool should be

(a) Fast (b) Medium
(c) Slow (d) Normal

15) In grinding process metal is removed from _________

(a) 0.15 mm to 0.20 mm
(b) 0.25 mm to 0.50 mm
(c) 0.15 mm to 1.00 mm
(d) 0.30 mm to 0.80 mm

16) The least count of a depth micrometer is

(a) 0.001 mm (b) 0.01 mm
(c) 0.002 mm (d) 0.02 mm

17) A grinding wheel is a _________

(a) Single point cutter
(b) Multi tooth cutter
(c) Double point cutter
(d) Three point cutter

18) Grinding is basically a _________

(a) Turning process (b) Planning process
(c) Shaping process (d) Machining process

19) The reading of a vernier dial gauge is similar to _______

(a) Plug gauge (b) Dial gauge
(c) Vernier gauge (d) Depth gauge

20) Surface roughness of turned components in microns will be

(a) 0.012 to 0.2 (b) 0.32 to 25
(c) 32 to 250 (d) 100 to 500

21) Feed in lathe is expressed in _______

(a) mm per revolution (b) mm per degree
(c) mm (d) rpm

22) Grinding process removes metal by a________

(a) Larger volume (b) Very Larger volume
(c) Medium volume (d) Smaller volume

23) The milling cutter used for milling convex shapes is

(a) End mill (b) Form mill
(c) Slab milling cutter (d) Angle milling cutter

24) In case of helical milling cutter when viewed from end if flutes move in clockwise direction it is called

(a) Left hand helix (b) Upper helix
(c) Right hand helix (d) Lower helix

25) First piece inspection should be carried out for all the dimensions given on the drawing

(a) Cannot say (b) False
(c) True (d) None of the above

26) Ceramic cutting tools retain hardness up to

(a) 10000C (b) 12000C

(c) 8000C (d) 9000C

27) Grinding process employs a rotating _______

(a) Cutting tool (b) Forming tool

(c) Shaping tool (d) Grinding wheel

28) The method of expressing the surface roughness. CLA refers to

(a) Class line average (b) Centre line average

(c) Class line area (d) Centre line area

29) The base of cylindrical grinding machine is made out of

(a) HSS (b) Cast steel

(c) High carbon steel (d) Cast iron

30) What is ATC?

(a) Automatic tool changing (b) Auto tool cutter

(c) Advanced tool changing (d) Advanced tool cutter

D-2-15. Sheet for Monitoring (AIEMA)

08/09/2016

Prepared by: Masato Dohro (JDS)

Repeat Pilot Monitoring at AIEMA : Planned on 02/12/2016

1) Vernier, micrometer, scale

Why? As some Japanese companies expect the candidate to have sound knowledge on their use, they must be trained at least up to the **basic level**.

2) Details of Pilot Monitoring

a) Proper measurement method using Vernier
b) Proper measurement method using micrometer
c) How to correctly read Vernier and micrometer
d) Proper measurement method using scale

3) Changes in measurement

		Before	After
a)	Scale	12 inch	6 inch
b)	Vernier	Large	Conventional

4) Pilot monitoring on December : 3 students (NC lathe) + 3 students (NC milling)

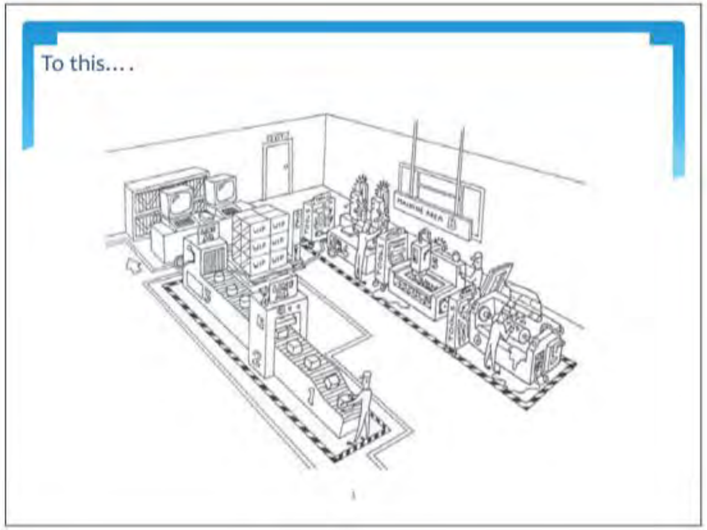
Duration : 2 to 3 hours

5) Countermeasures

Allocate more time to teach the necessary methods before the next monitoring session.

D-3. Soft Skills

D-3-1. KAIZEN (5S+1S, ITI Mint)



What does 5S mean ?

1 **S**eiri — **S**ort (necessary,unnecessary)

2 **S**eiton — **S**tore (where for keep)

3 **S**eiso — **S**hine (cleaning)

4 **S**eiketsu — **S**tandardize

5 **S**hukan — **S**ustain (Habit)

1 S Sort

Separate the necessary goods from unnecessary goods and throw away unnecessary goods

1 S Sort

Remove unnecessary tools, equipment, files, furniture, and anything unnecessary from the work area

Sample checklist:

- Are there unnecessary stock at the work shop?
- Are there cables/equipment lying around?
- Are there tools or materials on the floor?
- Are all tools/measuring instruments labelled?

2 S Store

*Create a place for all necessary goods

*Need to pick up the tools easily.

2S Store

Organize the necessary items!!

Use simple and clear labelling and procedures!

3S Shine (cleaning)

Removal of dirt, grease, dust, chips, etc.

Important is that everyone joins in!

Important is that we must clean everyday !

3S Shine

Oil/ water leak

Gas leak

Broken window

*Find the cause!!

*Take corrective action!

Dust

Too dark

REPAIR!

Too hot

3S Shine

Work places and office should be Shined!!

* Everything should be cleaned, painted or repaired to made to look like new.

3S Shine

Check list (sample)

(Office)

* Did you clean the floor, cabinet, desk or shelves (any unnecessary documents, dust or dirt)?
* Are lights dirty ?
* Are there broken windows?

4S Standardize

Standardize procedures for continuous cleaning

Making " 5S" rules by management in order to continue the clean conditions

Chips scrapping system

Machine repair system

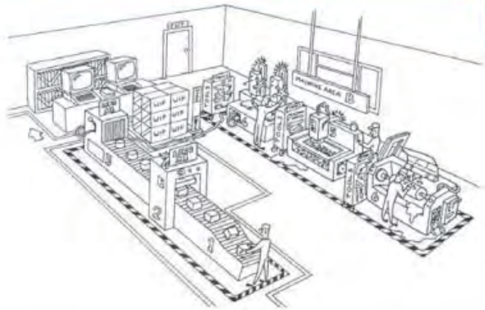
Daily cleaning system

5S Sustain

GET into the habit!!

Management also must be involved continuously in Cleaning activities.

5S -Sustain is important



Summary

1	Sort	Separate : Necessary/unnecessary goods
2	Storage	Everything has a place (Storage places for goods)
3	Shine	Cleaning of area & equipment Everything should look like new
4	Standardise	Create a standard to maintain the work area -> A Visually Clean Work place
5	Sustain	Maintain the Standard

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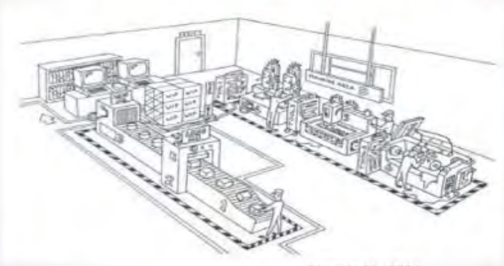
D-3-2. 5sets of S

Plan of Activities with Vocational Training Institute Teachers in the Machining Field

5S (5 sets of S)



March 26, 2016
Kunimori OGIYAMA
Japan Development Service Co., Ltd.

1

5S Activities

What is the 5S ?

✱Generally, factories are messy with equipment and tools

✱A messy work place can be dangerous and decreases work efficiency

✱ 5S is a method to improve such problems.

✱5S is the name of a workplace method of keeping everything in order

That uses five Japanese words converted in English

2

✱5S refers to fundamental activities to develop improvement

✱Improvement can bring success and happiness in a people's life

1	Seiri	Sort (necessary, unnecessary)
2	Seiton	Store (where for keep)
3	Seiso	Shine (cleaning)
4	Seiketsu	Standardize
5	Shukan	Sustain (Habit)

3

1 S Sort

Separate the necessary
from the unnecessary items,
and throw away the unnecessary items

4

2S : Setting and storing in order

*Keep needed items in appropriately according to usage-frequency.
*Classification 1 : Use everyday
Keep visual controls at the places in workshop for easy access.
*Classification 2 : Use several times in a month
Keep in a tool box in the workshop.
*Classification 3 : Use several times in the past 3 years
Keep in a storehouse in the factory.
*Classification 4 : Not-used in the past 3 years
Sell as used part or scrap, otherwise dispose as waste.

2S Store

Organize the necessary items!!

Use simple and clear labelling and procedures!

Tool: spanner, wrench, hammer

Sling wire, shackles

Welding cables

9

3S Shine

Some areas already started cleaning.

10

3S : Shining or Cleaning

- 3S is to improve dusty places and maintain good health of workers and good quality of products
- 3S will be effective when you continue implementing 1S and 2S, and keep the workshop clean
- Better evaluation can be obtained from clients

11 11

Good sample of 5S in Work shop in China

This work shop started 5S in year 2010.

Machinery work shop at present (2016.04.16)

26

12

Walk way of structual work shop at present
(2016. 04. 16)

13

4S Standardize

How to do daily cleaning?

How to store tools and jigs?

How to make repair plans?

14

5S Sustain

GET into the habit!!

Management must to ask workers for cleaning EVERYDAY and join in it.
This is not only the WORKER'S JOB.
YOU must be involved in it as a KEY person.

15

5S : Sustaining, Training and Discipline

✱5S will take effect when you get into the habit of implementing 1S to 4S

✱5S is the foundation for the company to start developing improvement activities

✱5S's discipline will lead to enhancing the mind for improvement

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Summary

1	Seiri	Separate : necessary/unnecessary Good Position/bad position
2	Seiton	Everything has a place
3	Seiso	Cleaning of area & equipment Everything should look like new
4	Seiketsu	Create standard to maintain the area Visually Clean Work place
5	Shukan	Maintain the Standard

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Effects of 1S and 2S (Sorting and Setting in order)

* Improve work efficiency (Saving time by finding items easily)
* Reduce work fatigue (Reducing fatigue by save time mentioned above)
* Maintain safe working (Prevent from stumbling and reduce risk of injury while handling)

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* Maintain good storage (Easily notice missing items : same items should be put in the same place)
* Improve work quality (Worker's mind can also
* put in order, by concentrating on the job without taking notice of other things and therefore improve work quality

19

5 S is not difficult to practice. The important thing is to get started

* Once we start, we must devote ourselves to implement 5S activities
* We can be happy and have confidence when we see the effectiveness

20

* 5S should be implemented by all employees of the company

* 5S is desirably implemented by a number of teams, formed from an optimum member size

* 5S aims at cooperation and implementation as team activities, and to show team power for the target

5S is activities without much cost and reduce the production cost

* 5S activities will reduce the production cost by good work efficiency

* 5S activities will reduce the repair cost by good quality of the products

5S is for workers

* Workers improve working environment for working pleasantly and hopefully

* 5S results in good production performance and contributes to the company's achievement

* 5S also can supply inexpensive good quality products to customers

* The above merits will bring happiness to all workers

Fundamental ideas for promoting 5S are as follows

* 5S should be implemented with all employees of company

* The top manager should explain the purpose of 5S to all members clearly

* All members should understand its purpose.

* Implement in the order, from 1S, 2S, 3S, 4S to 5S.

* Desirably implemented by several teams as team activity

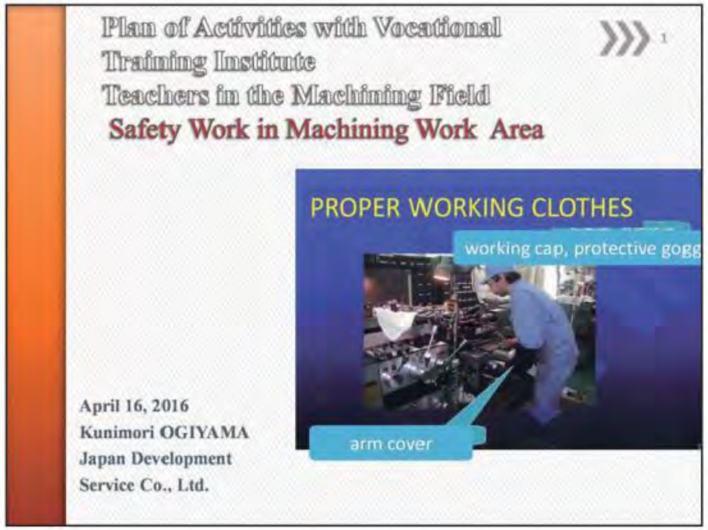
* Implement with schedule list and understand the progress

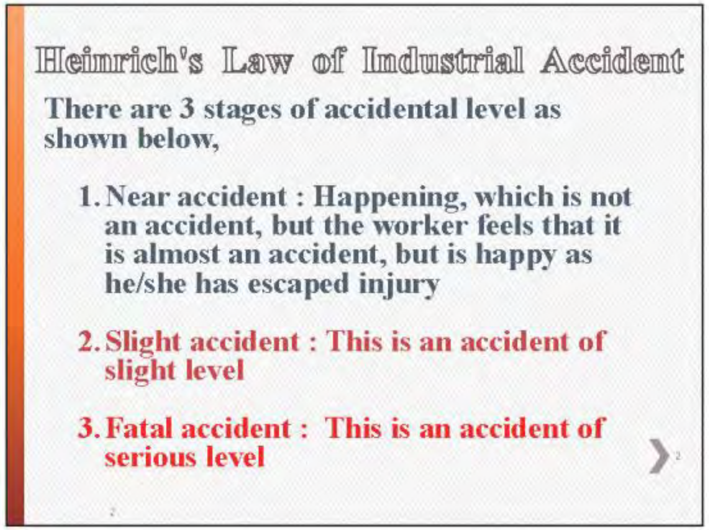
* Implement progress with visual control and own all information in common

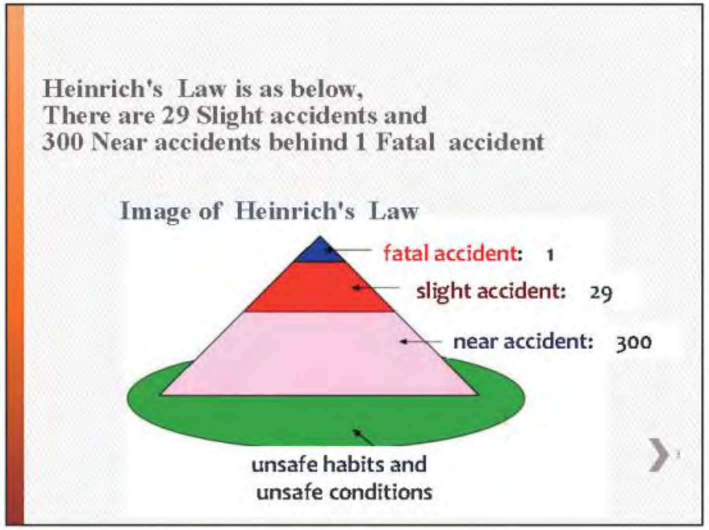
Structual work shop at present (2016.04.16)

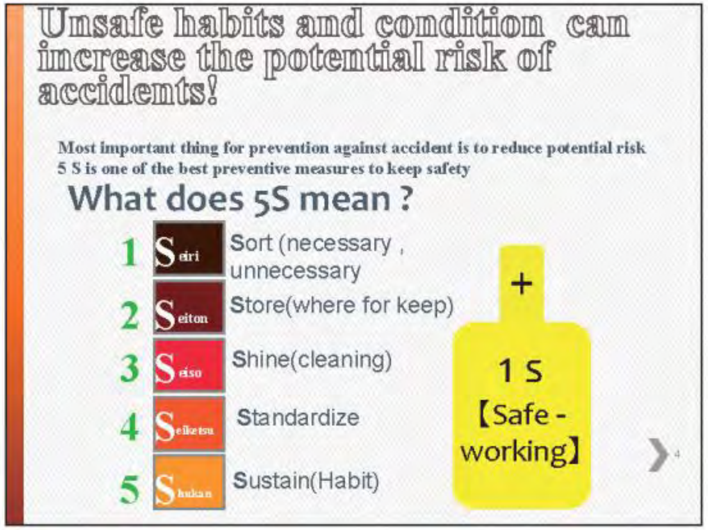
Earlier condition of the structual work shop (2009.04.09)

D-3-3. Safety Work in Work Area









What is the Carelessness ?

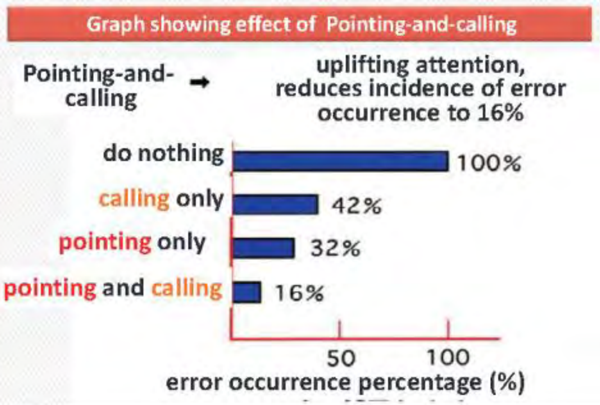
1. Misunderstanding of objects
   - mistake in vision
   - mishearing
2. Mistake from forgetfulness
   - carelessly forget
3. Operational mistake
   - Discrepancy of movement between brain and arms and legs

Accidents and disasters can occur associated with the above 3 mistakes

Best countermeasures for preventing carelessness

1. Pointing-and-calling can reduce careless mistakes to 16% and improve by 84%
2. Pointing only can reduce careless mistakes to 32% and improve by 68%
3. Calling only can reduce careless mistake to 42% and improve by 58%
4. Without pointing-and-calling, mistakes cannot be reduced

Uplifting attention by pointing-and-calling can reduce accident risks



Safety control policy

1. Advance meeting for safety study
2. Make work manual
3. Practice meeting for risk prediction
4. Practice 5S of Sorting, Storing, Shining and Standardizing
5. Promotion of Pointing and Calling for safety confirmation
6. Periodical inspection of machines and equipment

1 S Sort

Separate the necessary items from the unnecessary items and throw away the unnecessary items

Safe management of machines

General attention

1. Operation shall begin after receiving enough lessons and understanding their contents well
2. Before starting operation, confirm and watch surroundings surely by oneself
3. When something unusual is felt (sound, smoke, smell, heat, vibration), stop the operation immediately and contact the person in-charge
4. While performing (cleaning, repair, inspection, machine lubrication), stop the operation and switch off before performing it

5. Cover rotating parts (gear, belt, shaft, grinding wheel)
6. Do not stop the machine with hands, legs and tools while machine is still rotating under own inertia
7. When the blackout occurs, ensure that the power is switched off
8. Do not stretch your hand to the opposite side beyond and over the rotating machine or parts
9. When the operation is finished, return switches to the original position of OFF
10. Remove obstacles like blocks and bars scattered on the work floor to prevent stumbling over them

Safety management of machines

Tools

1. Treat tools with care
2. Use tools appropriate for the work (not too big or too small)
3. Defective tools such as chipped or loose tools, shall be scrapped if it is not possible to repair them
4. Keep tools always in order
5. Use protective goggles whenever necessary
6. Do not neglect tools in safety work

Tools : Hammer and Spanner

Safety management of machines

Processing machine

1. In principle, do not use gloves, especially for drilling machine and lathe
2. Use working clothes with sleeve and hem closed, and do not hang towel from the belt
3. Use protective goggles and mask under dusty condition
4. Do not apply oil on the machine handle or tool to avoid slipping
5. Face and hands should not be close to the rotating parts while processing

6. After the machine completely stops, then can do fitting tools, removing tools and checking the measurement
7. Apply processing oil using brush, and take care not to get injured at the rotating parts
8. After machine completely stopped, the processing chips can be removed with brush
9. While working, always wear shoes, not slippers or sandals

safety shoes

Safety management of machines

Lathe - 1

1. After confirming that all switches to be off, then turn on the main switch
2. Before starting lathe operation, check the inspection items, lubricate if necessary
3. Observe starting sound and operating sound
4. After tightening the bite, remove the tool chuck handle, and then start rotating
5. The work and chuck should be fitted tightly to the velum
6. The work shall be aligned well in centering

7. Turn on main switch after setting rotation speed of main shaft and feeding speed correctly
8. In cutting the work, the cut off work piece should not hit the automatic tool slide and tool rest

Lathe

9. Do not stand position within the rotating circuit area, where chuck and other rotating parts are fixed

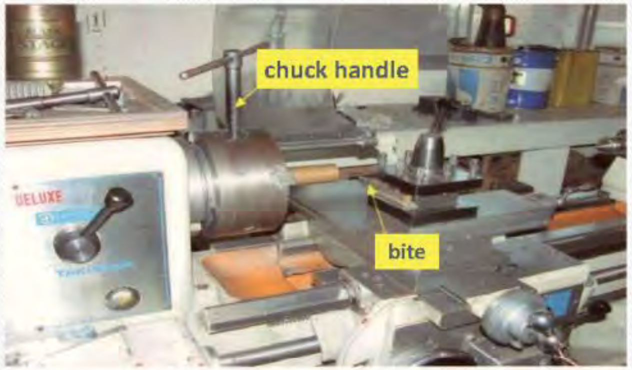
10. Long sized work should cut and fixed with chuck.

11. Do not rotate without fixing the workpiece with the chuck

Proper clothes : working wear, cap, arm-covers, goggles

17

Lathe bad example: retaining the chuck handle, work hits the tool rest



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Safety management of machines

Lathe - 2

1. Do not try processing using blunt bite
2. Fix the bite after centering
3. Begin processing after performing the following,
   - Keep bite safety away from workpiece
   - Rotate the main shaft and ensure that the bite does not to touch the workpiece
   - Approximate the bite to the workpiece gradually

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4. Do not put your finger into the hole of the workpiece while processing
5. Do not remove the safety device without authorized permission
6. Do not go away from lathe while processing automatically
7. Do not put rug near at the bite so that it is not caught in it
8. When stopping the motor, cut off the clutch fixed on the middle of the shaft
9. When the working is completed, turn off all switches and remove and replace tools to their original place, then clean the workplace

20

Safety management of machines
Drilling machine

1. Do not use drill cutter which is not sharpened enough
2. Fix the drill tightly and remove the chuck tightening tool before starting the operation
3. Set the drill with proper rotation number
4. Do not press the drill too much against the workpiece

Drill Machine

5. Perform lubrication properly
6. When finishing the drilling till the end, take care during break through the workpiece
7. While breaking through the workpiece, if the drill stops rotating, or rotates together with the workpiece, turn off switch and perform recovery after the main shaft has stopped completely
8. After finishing the work, turn off all switches and remove and replace tools to their original location, and then perform cleaning

Fix work with vice, not by hand

Use of Gloves is prohibited, especially for Lathe processing and Drilling

Remove processing chips with brush, not by hand

Safety management of machines

Grinder

1. Fix and tighten the grinding stone
2. Do not use grinder with crack on the grinding stone
3. Rotate with no load operation and confirm that there is no abnormal sound or vibration, and then start grinding
4. Do not neglect (forget) to sharpen the grinding stone
5. Start the grinding after maintaining steady rotation
6. Do not push the work too much against the grinding stone, and do not grind using the side face of grinding stone

7. Put the workpiece on the grinding table and do not remove the work from the table while grinding
8. Take caution to avoid burn injury when the workpiece gets heated by grinding
9. Do not stand at directly too near in front of grinding stone while grinding
10. Use protective goggles and mask while grinding
11. After finishing the grinding, clean well

Grinder

use safety protection for welding : safety helmet, face shield, leather gloves, shoes

Safety management of work shop

Safety management will be better, to begin and promote as a company's activity where all members join in.

Company displays safety principles such as,

- Safety shall precede any other matter
- Company shall not make workers to do, and workers shall not do Unsafe work
- Foresee accident risks
- Observe rules
- Take effort by yourself

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Company uses safety slogan such as,

- Check safety before work!
- Dangerous!! Your Calling can protect from accident
- Do not forget!! Standard operation and foresee accident risks
- Safe work through continuous standard operation
- Remember original intention even for practiced jobs

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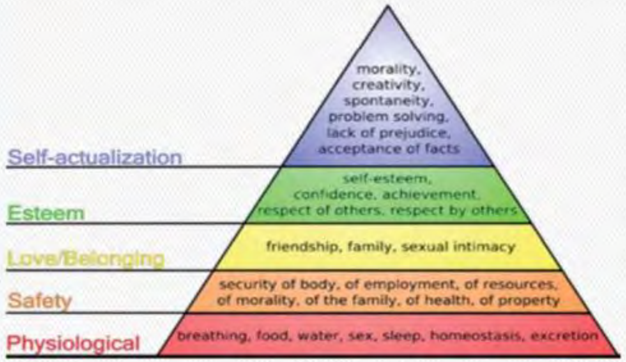
Example picture of Safety Rules



Why Safety is First?

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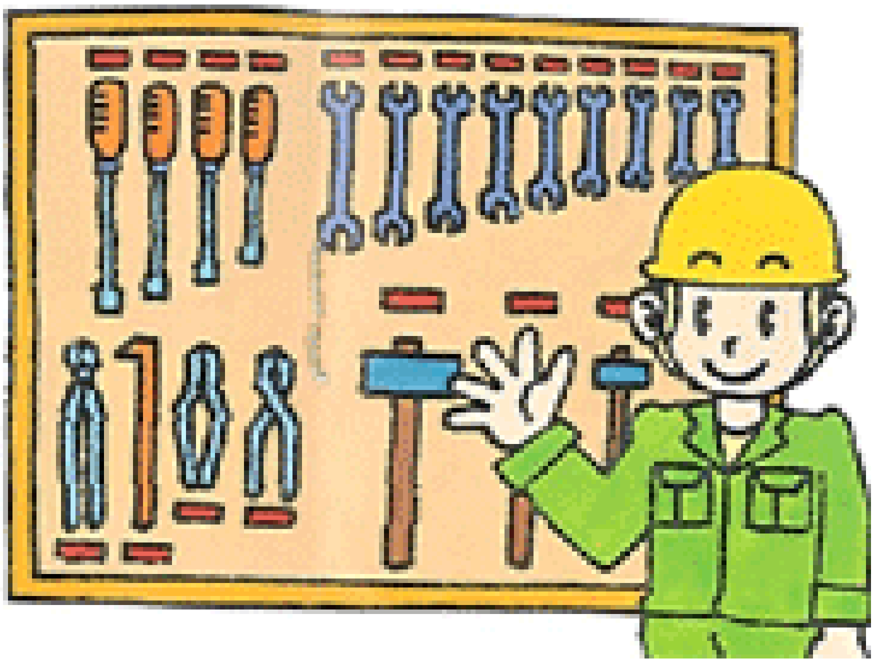
D-3-4. Sample of Improvement

Improvement – 1. Tool Box

Sample -1 : Portable Tool Rack

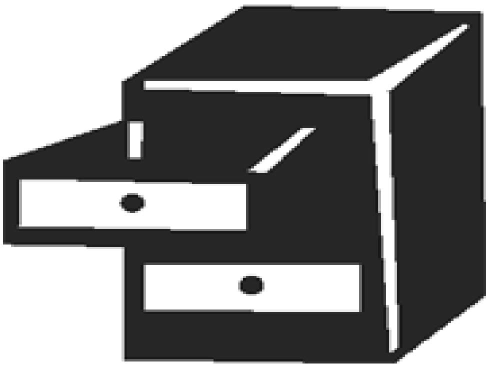
Sample-2 : Visible Tool Table



Improvement – 2. Label showing contents

Sample-1. Label showing in Box

Sample-2. Label showing in Drawer and Locker



D-3-5. Disposal of Processing Chips

Plan of Activities with Vocational Training Institute

Teachers in the Machining Field

Metal Special Character and
Disposal of Processing Chips

March 26, 2016
Kunimori OGIYAMA
Japan Development
Service Co., Ltd

1

Metal Special Character

- Regarding the metals used widely in automobile and industrial machine, special character and processing care items per each metal are shown in table 1.

2

Table-1. Special character and processing care items

Symbol of metal	Component Special character	Processing care items
Steel (FC)	Iron(Fe) + Carbon(C): Carbon steel is most used in metals	Good machine-ability Alloy steel is sticky difficult for processing
Copper (Cu)	Copper(Cu): Malleability and anti-rust ability , no use for structure	Good machine-ability but easily fused. Super-hard alloy bite
Brass (CuZn)	copper(Cu) + Zinc(Zn): Malleability and strength are good. Use for mechanical parts	Difficult processing by built-up edge and hardening. High-speed bite
Aluminum (Al)	Alumi(Al): Light-weight and anti-rust ability, no use for structure	Difficult processing by built-up edge and hardening. Super-hard alloy bite
Alumi alloy (AlCu,AlMn	Al + Cu, Mn : Light-weight and anti-rust ability. Use mechanical parts	

Summary Metal Special Character

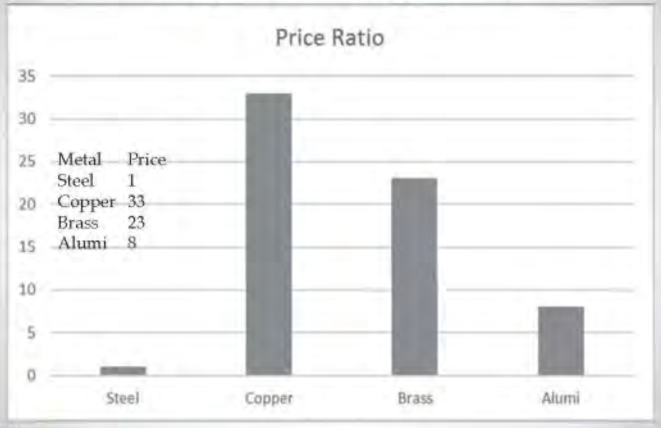
Metal/ Mechanical use	Machine ability	Strength	Anti-rust ability
Steel ◎ Best	◎	◎	×
Copper ○ Good	○	○	◎
Brass ◎ Best	△Can	◎	◎
Aluminum × BAD	△	×	◎
Al-alloy ◎ Best	△	◎	◎

Disposal of Processing Chips

Table-2 Scrap price of processing chips

Material Gravity	Scrap price: INR／kg (JPY/INR=1.68)	Price comparison with Steel
Steel 7.8	9- 12	1
Copper 8.8	300 - 360	25 - 40
Brass 8.5	210 - 240	18 - 27
Aluminum、Al -alloy 2.7	60 - 95	5 - 11

Scrap Price Comparison



6

(1) Scrap price of **copper** is higher by 25 to 40 times to iron. **Brass** is higher by 18 to 27 times , **aluminum** is higher by 5 to 11 times to iron.

(2) Automobile and motor-bike are made by mass production, and used copper and aluminum material.

(3) Separating disposal of processing chips of **copper and aluminum from Iron** , can make money by recycle.

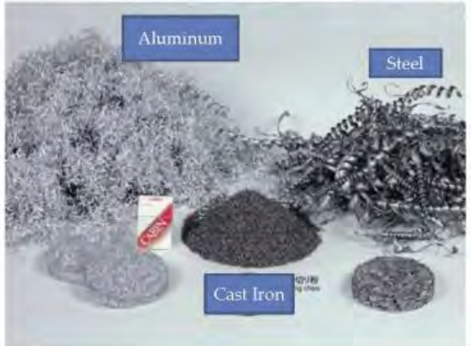
(4) Separating disposal of processing chips helps to practice **Sorting ,Setting in order.**

Workers are used to do sorting and setting in order every time after finishing one job. Workshop turns into **clean and shining.**

(5) Separating disposal of processing chips leads to next step of **5S activities.** You are expected to start 5S.

Separating disposal of processing chips

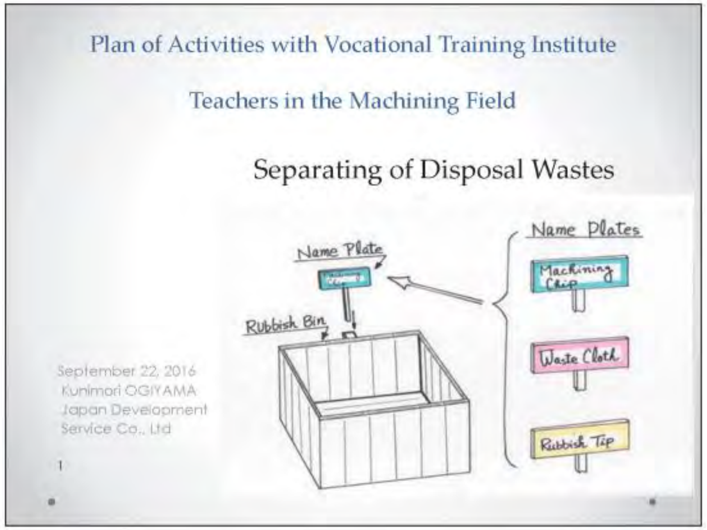
Processing chips of Iron and Aluminum

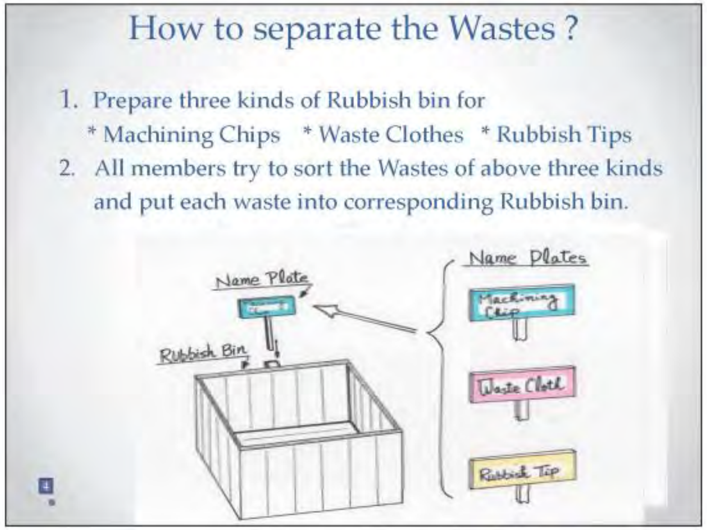


Processing chips of Brass

Disposal of Copper wire

D-3-6. Separating of Disposal Wastes





Main Point on Employment ①

Question on Employment Interview

by Japanese Company in Chennai

Q 1. Do you know about **5 S** ?

Q 2. Do you know about **KAIZEN** ?

Q 3. Can you work at two-shift and three-shift ?
* Night work

Q 4. Company wants to employ for Paint-shop
(Person wants to work for Machine-shop)

Q 5. Bad school reports are due to one's lazy, or owing to teacher ?

Main Point on Employment ②

Teacher should teach followings clearly to students

1. 5S and KAIZEN are main points for growth
2. Separating wastes is the first step for working

------- Following person can get jobs ------

3. Person who keeps doing inconspicuous and simple job with a sense of responsibility
4. Person who take effort to improve with progress mind
5. Person who learn the grounding and basic work of Machining

APPENDIX E:

TNSDC NOTICE LETTER

Appendix E: TNSDC Notice Letter

TAMIL NADU SKILL DEVELOPMENT CORPORATION

From

Thiru C. SAMAYAMOORTHY, I.A.S.,
Director,
TamilNadu Skill Development Corporation
Integrated Employment Offices Building
1st floor, T.V.K industrial Estate
Guindy, Chennai 600 032.
Email-Id: dettnsdm@gmail.com
Phone No:044-22500107

To

Mr.Akira Doi,
Japan Development Service Co. Ltd.,
Tokyo, JAPAN
email: doi@jds21.com

Rc.No. 526/SDC-1/2016-2 Date:- 27 .4.2016

Sir,

Sub: TNSDC – TNIPP Programme of JICA – Japan Development Services Co. Ltd – Skill Development Activities in our state – Linkage between Japanese Companies and Government ITI's - Regarding.

Ref: Your letter no Nil dt: 15.4.2016

Japan Development Services Co. Ltd (JDS) has requested TNSDC to provide linkage between Japanese companies and Government ITI's. In this regard it is informed that JDS or Japanese companies can interact directly with all Government ITI's . Regional Joint Director of Five Region in our state and Joint Director (ATS) under the agencies of Development of Government ITI's by constituting Institute Managing Committee. The contact numbers of the Government Principals and Regional Joint Director as well as IMC guidelines are enclosed here for information.

Encl: 1. List of Contact Numbers
2. IMC Guidelines

for Director
28/4/16

Copy to
1. Joint Director (ATS)
2. RJD (Training) Chennai, Madurai, Coimbatore & Trichy and Tirunelveli Region

} For information necessary Action

APPENDIX F:

EQUIPMENT AND MATERIALS FOR TOT AT ITI MINT

Appendix F: Equipment and Materials for ToT at ITI Mint

1. Metal Work

No.	Name	Remarks	Weight of Metal (per unit)	Size (per unit)	Unit	Purchaser
1	Monthly chart of pre-operation inspection sheet & vinyl sheet	Vinyl sheet (A4 paper)	—	about 300mm×200mm	16	ITI Mint
2	Paint for gear change of conventional turning machine	Red paint	—	about Φ100×100mm	1	
3	Chuck handle of conventional turning machine	Steel quenched	—	about 450mm×250mm	1	
4	Coolant of conventional turning machine	Coolant & cutting fluid	—	about 500mm×20mm	1	
5	Drawing table beside conventional turning machine	Stainless steel/iron (?)	—	about 300mm×600mm	16	
6	Metal for step turning (ToT and monitoring)	Iron	about 1.0~1.5kg	about Φ61×89mm	4	
7	Work table beside conventional turning machine	Wood	—	about 500mm×800mm×800mm	2	
8	Light for conventional turning machine	Light for industrial use	—	about 800mm×150mm	2~	
9	Feed handle grip of conventional turning machine	Plastic grip	—	about 100mm×15mm	3~	
10	Lever grip of tool post	Plastic grip	—	about 100mm×30mm	1	
11	Lever of tool post	Steel quenched	—	about 200mm×100mm	1	
12	Tool centre height adjustment jig	Stainless steel	—	about 130mm×60mm	1	
13	Metals (for training of difference of chips of various metals)	Iron Aluminum Stainless steel Copper Brass	about 1.0~5.0kg	about Φ65×75m	1 each	JICA Project
14	Brush(for cleaning of turners	—	—	—	18	
15	Digital vernier caliper	—	—	—	2	
16	Vernier caliper	—	—	—	7	
17	Linear scale	—	—	—	7	
18	Chamfering tool	—	—	—	1	
19	Tuning tool holder	—	—	—	1	
20	Rough turning chips (Iron)	—	—	—	2	
21	Rough turning chips (Aluminum, Brass, Copper)	—	—	—	2	
22	Rough turning chips (Stainless steel)	—	—	—	2	
23	Cutting-off holder	—	—	—	1	
24	Cutting-off tool chips (with 3mm)	—	—	—	2	
25	Work gloves	—	—	—	15	

2. Welding

No.	Name	Remarks	Weight of Metal (per unit)	Size (per unit)	Unit	Purchaser
1	Mask	General type	—	—	?	ITI Mint
2	Expendables for installment of the spot welding machine	Piping and electricity installment	—	—	1 set	
3	Metal materials(bead on plate, fillet welding, gas cutting, gas welding)	Reuse of used steel materials	?	?	?	
4	metal materials(bead on plate, fillet welding, gas welding)	from school inventory	about 0.5kg	about 80mm×150mm×6mm	~10	
5	Metal materials (for Arc Welding)	Plain carbon steel/Mild steel	2.0kg	10mm×100mm×250mm	25	JICA Project
			1.2kg	10mm×75mm×200mm	75	
			2.4kg	10mm×150mm×200mm	50	
			1.6kg	10mm×100mm×200mm	50	
			?	5~6mm×30mm×220mm	25	
6	Metal materials (for RW)	Cold roll sheet	0.0236kg	1.0mm×30mm×100mm	250	
7	Flame retardant coverall	—	—	—	10	
8	Welding gloves	—	—	—	10	
9	Welding apron	—	—	—	10	
10	Welding arm sleeve	—	—	—	10	
11	Welding leg guard	—	—	—	10	
12	Safety shoe foe welder	—	—	—	10	
13	Welding goggles	—	—	—	10	
14	Dust respirator	—	—	—	15	
15	Work gloves	—	—	—	15	
16	Expendables for installment of the spot welding machine	—	—	—	1 set	
17	Jig parts for spot welding training	—	—	—	1 set	
18	Grinding machine	—	—	—	10	
19	Spot welding machine	Including accessories	—	—	1	
20	Welding pressure gauge	Including accessories	—	—	1	
21	Ammeter	Including accessories	—	—	1	
22	Air compressor	Including accessories	—	—	1	