CNC EDM
POWER SUPPLY
INSTRUCTION MANUAL

DIMON BEIJING CNC TECHNOLOGY CO., LTD.

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CHAPTER1. MACHINING CONDITION PARAMETERS

1. Configuration of CONDITION FILE

1) "CONDITION FILE" is designed to allow manual cutting or input of files/programs on an individual basis to be executed using such a C code selected from the machining performance table as can almost meet its requirement in order to save the trouble of inputting the group definition of the C code on each of such occasions.

2) "CONDITION FILE" is loaded onto the RAM MEMORY when the system loading is performed, thus allowing any C code, if saved in the file, to be called into all programs to be executed in the "Manual cutting" and "User cutting" modes. The CONDITION FILE contains a total of 60 machining conditions created by combining 10 conditions for machining from roughing to finishing with six basic parameters (ON, OFF, IP, V, SV, PL) selected according to the electrode/ work piece material combination and allowable electrode wear ratio.

The parameters in the C codes are organized by taking consideration of the material combination and machining performance, and served as references to understand the software of the system.

3) The C code Nos. that can be saved into and loaded from the CONDITION FILE are CI00 to C899.

The number of C codes actually used in the file is 80 to 100, allowing the rest of the codes to be used on the user side for creation of a new C code list.

100 conditions from C000 to C099 are intended for use in individual files.

In addition, C codes from C 900 to C999 are used for PIKA machining conditions.

C000 - C099 - - - - Private machining conditions

CI00 - C899 - - - - Public machining conditions (CONDITION FILE)

C900 - C999- - - - PIKA machining conditions (CONDITION FILE or PIKA file) C codes,000 - 099 can be duplicated in individual files.

2.Categorization of CONDITION FILE

Category	Code No	Description
Cu-St no-wear(A)	CI00 - C190	Copper-steel machining condition with 'highest consideration electrode wear ratio according to IP
Cu-St no-wear (B)	C200 - C290	Copper steel machining contusion with consideration to efficiency according to IP Copper/tungsten-steel machining condition with no electrode wear.
Cu-St low-wear	C300 - C390	Copper-steel machining condition favorable for finishing punching
Gr-St low-wear (A)	C400- C490	Graphite-steel machining condition
Gr-St low-wear (B)	C500 - C590	Graphite-steel machining condition
Gr-St with electrode wear	C600- C690	Graphite-steel machining condition for punching
CuW-WC	C700-C790	Carbide machining condition with electrode wear
CuW-Cu; Cu-St	C800-C890	Machining condition under discharge control using capacitor circuit with electrode wear
Cu-St no-wear	C900-C903	PIKA machining condition for supper finishing to produce a mirror surface
Cu-St no-wear	CI0I- C191	PIKADENI
CuW-St low-wear	C102- C192	PIKADEN2
Cu-St with electrode wear	C301- C321	PIKADEN3

The C codes categorized as shown in the above table have been saved in the CONDITION FILE as a SODICK original file.

if any new C code is to be input in the CONDITION FILE on the user side, select the "MACHINE SET - PARAMETER" screen for parameter change, audition or deletion,

PIKA circuit: Mirror surface finishing circuit

PIKADEN: Current control circuit

3. Classification of C Code Parameters

The "NF" series has 20 C code parameters for machining condition setting as indicated in individual files including the "CONDITION FILE" or the execution C code display area. The 20 parameters are classified into the following three types:

(1) Parameters for discharge pulse control

(2) Parameters for machine control

(3) Parameters for LORAN operation control

List of C Code Parameters

Classification	Parameter	Main Function
(1) Discharge pulse control	ON	Discharge pulse ON time
	OFF	Discharge pulse OFF time
	IP	Main power supply peak current
	PL	Polarity
	V	Main power supply voltage
	HP	Auxiliary power supply circuit
	PP	PIKADEN pulse control
	AL	Abnormal discharge detection level
	OC	ONCUT control level
	LD	ON/OFF control speed setting
(2) Machine control	MA	Discharge OFF pulse duration control
	SV	Servo reference voltage
	UP	AJC operation up time
	DN	AJC operation down time
	C	Discharge gap capacitor circuit
	S	Servo speed
(3) LORAN operation control	LN	LORAN operation pattern selection
	STEP	LORAN operation excentric radius from machining axis center
	L	LORAN operation speed
	LP	QUADRANT LORAN operation Pattern

4. Description of C Code Parameters

(1) Parameters for discharge pulse control

ON: This parameter is used to set the duration time of the 1 - pulse EDM spark.

The setting is made in the range of 0-63/100-107.
For the relationship between the parameter setting and its corresponding pulse duration time, refer to Appendix 1-1.

OFF: This parameter is used to set the duration time between EDM sparks. The setting is made in the range of 0-63.

For the relationship between the parameter setting and its corresponding time duration, refer to Appendix 1-1 .

IP: This parameter is used to set the peak of the discharge current generated by 1-pulse EDM spark.

This is an important parameter which is combined with the parameter "ON" to determine the machining rate, surface roughness, electrode wear ratio, discharge gap and other machining conditions.
The parameter can be input in increments of 0.5 and its maximum input value varies according to the model as shown below:
NF 25 ...... 1515 max.
NF 40 ...... 31.5 max.
NF 80 ...... 63.5 max.
For the parameter input method and peak current, refer to Appendix 1-2.

PL: This parameter is used to set the electrode/work piece polarity by input of + / - with the Z axis (normally electrode) side as reference for the setting.

For the parameter setting method and precautions, refer to Appendix 1-3.

V: This parameter is used to select the main power supply voltage to supply the iP current
The parameter can be set by selecting from the 10 levels of V0 to V9:
V l → Cu-St machining
V2 → Gr-St/CuW-WC machining.
For the parameter setting method and precautions, refer to Appendix 1-7

HP: This parameter is used to set the control circuit, high-voltage pub addition circuit ad other circuits provided separately from the IPN-controlled main power supply circuit r order to control EDM spark pulses according to the electrode .- work piece material combination and machining status.
For description of the function, refer to Appendix 1-4

PP: This parameter is used to set the PIKADEN pulse control.

PP	Function
00	High voltage control and P11 (ADEN OFF)
01	Only PIDADEN control ON
10	Only high voltage control ON
11	High voltage control and PIKADEN ON

◆ For the parameter setting method and effect to Appendix 1-5

AL: This parameter is used to set the level at which to detect any abnormal discharge for each machining condition.

The parameter setting can be changed in the range of 0-63 with 33 as a reference level.
The higher the setting, the higher the machining rate and the higher the possibility of arcing between the electrode and work piece.
For details on the parameter setting method, refer to Appendix 1-6

OC: This parameter is used to set the ONCUT control reference pulse duration for each machining condition.

The parameter, which is normally set at "0", can be set in the range of 0-9.
The higher the parameter setting, the higher the effect of the control with resultant reduction in the possibility of arcing between the electrode and work piece.
For details on the parameter setting method, refer to Appendix 1-7.

LD: This parameter is used to set the ON/OFF control speed for' each machining condition.

The parameter, which is normally set at "0", can be set in the range of 0-9.
The higher the parameter setting, the higher the effect of the control with resultant reduction in the possibility of arcin9 between the electrode and work piece.
For the function and effect of the parameter, refer to Appendix t-8. ,
(2) Parameters for machine control
MA: This parameter is used to set the scale factor by which to increase the time duration between EDM sparks

MA:	0	1	2	3	4	5	6	7	8	9
Scale Factor:	xi	x2	x3	x4	x5	x6	x7	x8	x9	xl0

◆ For the parameter setting method and effect, refer to Appendix 2-1

SV: This parameter is used to set the servo reference voltage as shown in the following table, the data in which may vary slightly according to the machining condition.

- ◆ For description of the servo operation, refer to Appendix 2-2.
- ◆ For the setting of the parameter in the "Neuron learning" and "Fuzzy cutting", which is different from the above, refer to the instruction manual "NF POWER SUPPLY UNIT" provided as a separate volume.

UP: This parameter is used to set the manual jump up time, during which a tool electrode i.~ being raised, in the range of 0-9.

- ◆ For details on the parameter setting method, refer to Appendix 2-3.
- ◆ For the setting of the parameter in the "Neuron learning" and "Fuzzy cutting", which is different from the above, refer to the instruction manual "NF POWER SUPPLY UNIT" provided as a separate volume.

DN: This parameter is used to set the manual jump down time, during which a tool electrode is being lowered and in a position close to the work piece, in the range of 0-9.
For details on the parameter setting method, refer to Appendix 2-3

- ◆ For the setting of the parameter in the "Neuron learning" and "Fuzzy cutting", which is different from the above, refer to the instruction manual "NF POWER SUPPLY UNIT" provided as a separate volume.

C: This parameter is used to set the capacity of the discharge gap capacitor in the range of 0-9
This parameter is intended for use in finish-machining with high electrode wear rate, fine hole cutting and electrode forming.

C	0	1	2	3	4	5	6	7	8	9
Capacity: (μF)	0	.006	.012	.025	.05	.1	.2	.4	.8	1.4

- ◆ This parameter is intended for use in finish-machining with high electrode wear rate, fine Hole cutting and electrode forming.

S: This parameter is used to set the servo speed in the range of 0-9.

The parameter, which is normally set at 2-3, requires its setting to be increased for machining such as fine hole cutting, electrode forming and horizontal spindle cutting in order To prevent vibration of the servo axis.

S	01……………………………8.9
Servo speed	High Low

(3) Parameters for LORAN operation control

1) LN : This parameter is designed for input in three digits to select the LORAN Pattern plane, retraction mode and control pattern

① Select LONRAN pattern by setting 1st digit of LN to 0~5

LN
□□□
③②①

Setting	:0	1	2	3	4	5
Pattern	:OFF	O	□	◇	×	+

② Select combination of LONRAN plane and retraction mode by setting 2nd digit 0—8.

Setting	0	1	2	3	4	5	6	7	8
Plane	X-Y	X-Z	X-Z	X-Y	X-Z	Y-Z	X-Y	X-Z	Y-Z
Retraction mode	OFF	OFF	OFF	Path	Path	Path	Center	Center	Center

- Select “OFF” to halt LONRAN operation when an abnormal machining condition is detected
- Select “Retrace” to have the electrode to retrace the LORAN path when an abnormal machining condition is detected.

Setting	Control pattern
0	FREE LORAN
1	H.S LORAN
2	LOCK LORAN
3	THINK LORAN
5	QUADRANT FREE LORAN
6	QUADRANT H.S LORAN
7	QUADRANT LOCK LORAN
8	QUADRANT THINK LORAN

For a list of LORAN patterns, refer to Appendix 3-2

L: ① The 1 st digit of the parameter is used to set the LORAN speed in the range of 0-9

L □□

②①

Setting (1 st digit)	0,1…………………………8,9
LORAN speedily	Fast ———————— Slow

② The 2 nd digit of the parameter is used to select the direction of the LORAN operation in the range of 0-2.

Setting (2 nd digit)	Function
0	To rotate clockwise / counterclockwise alternately every. Two cycles of rotation.
1	To rotate counterclockwise.
2	To rotate clockwise.

The LORAN operation speed, when set fast, may result in vibration of the machining axis and the table depending on the machining condition, which in turn may result in unstable machining. If the machining state becomes unstable in this way, increase the setting of the parameter to decrease the LORAN operation speed.

STEP :This parameter is used to set the LORAN operation eccentric radius (discharge gap) in the range of 0-9999 in pm.

LP: This parameter is designed for input in four digits to set the QUADRANT LORAN pattern.

LN

□□□

④③②①

(1) LORAN pattern for the 4th quadrant

(2) LORAN pattern for the 3rd quadrant

(3) LORAN pattern for the 2nd quadrant

(4) LORAN pattern for the 1st quadrant

For details on the function of QUADRANT LORAN and a list of its patterns, refer to Appendix 3-2.

Appendix 1-1 ON/OFF Pulse Derisions Setting Table

ON(T on pulse duration)						OFF(T off pulse duration)			
No	u sec	No	μsec	No	μse C	No	μsec	No	μsec
00	1	30	50	100	2	00	2	30	3
01	2	31	60	101	3	01	3	31	4
02	4	32	70	102	5	02	4	32	5
03	6	33	80	103	8	03	5	33	6
04	8	34	90	104	10	04	6	34	7
05	12	35	100	105	14	05	7	35	8
06	20	36	120	106	20	06	8	36	9
07	30	37	140	107	30	07	10	37	10
08	18	38	160			08	15	38	12
09	30	39	180			09	20	39	14
10	40	40	200			10	20	40	16
11	60	41	220			11	20	41	18
12	80	42	240			12	20	42	19
13	100	43	260			13	20	43	25
14	120	44	280			14	20	44	30
15	150	45	300			15	20	45	35
16	180	46	320			t6	20	46	40
17	210	47	340			17	30	47	50
18	250	48	360			18	30	48	60
19	350	49	380			19	30	49	70
20	550	50	400			20	30	50	80
21	800	51	420			21	50	51	90
22	1000	52	440			22	50	52	100
23	1250	53	460			23	50	53	110
24	1500	54	480			24	250	54	120
25	1750	55	500			25	250	55	130
26	2000	56	550			26	250	56	140
28	2500	57	600			27	250	57	150
27	2250	58	650			28	250	58	165
29	2500	59	700			29	250	59	180
		60	750					60	195
		61	800					61	210
		62	850					62	225
		63	900					63	250

Appendix 1-2 IP: Main power supply peak current/micro peak current

V: Main power supply voltage

IP: This parameter determines the peak value of a current pulse.

Actually, peak value of current flowing across machining gap is defined by settings of IP.

The maximum IP value varies according to the model as exemplified below:

NF-25 IP 15.5 max

NF-40 IP 31.5 max

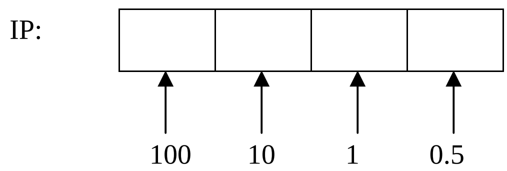
NF-80 IP 63.5 max

V: This parameter sets the voltage for the IP - set discharge circuit by input of 0-9 in its 1st digit as exemplified below:

V00:60V	V03=60V	V06=93V
V01=93V	V04=70V	V07=100V
V02 = 120V	V05=80V	V08=150V
		V09=180V

- Select V1 for machining under normal condition such as Cu-St machining.
- Select V2 for machining with Gr electrode, machining of WC material and other machining requiring a large current.
- V08,09 are only for Neuron cutting, they can not be used in any other mode.

Note 1:IP setting in condition area



Note: IP setting in program (B code STRING)

IP 1 2 3 (Code input) (Parameter)

digit of 0.1 IP 15 → IP 1.5

digit of 1 IP 150 → IP 15

digit of 10 →

Actual peak current values defined by settings of IP and V

V=No-load voltage	IP=peak current								
	0	0.5	1	3	5	10	15	31	63
1=93V	0	2A	3A	9A	15A	30A	45A	93A	189A
2=120V	0	2.7A	4A	12A	20A	40A	60A	124A	252A

Appendix 1-3 PL (Polarity)

This parameter selects the polarity of the Z axis, (+) or (-).

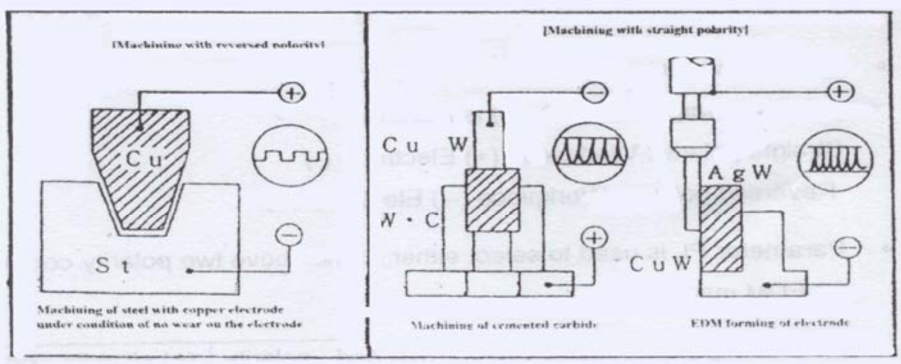
- In EDM machining, the relationship between the electrode and work piece in terms of polarity (straight or reversed) is important.
  Straight polarity: Work piece (+) Electrode (-)
  Reversed polarity: Work piece (--) Electrode (+)
- Parameter PL is used to select either of the above two polarity combinations as required for EDM machining.

Machining performance table Electrode setting	(-+) reversed polarity Tool electrode(+)	(+) straight polarity Tool electrode(-)
Tool electrode on Z axis quill side	PL= +	PL= -
Tool electrode on XY table side	PL= -	PL= +

- The PL setting is to be changed according to the work piece/electrode combination and the machining condition.
- Machining such as punching requires PL in the CONDITION FILE to be set in the reverse way.
- Improper PL setting has an adverse effect on the In chining performance, especially on the electrode wear.

  Example of PL setting for Cu-St machining
  Machining with no/tow electrode wear -- Reversed polarity
  Machining with electrode wear -- Straight polarity

  ⊙ In the case of such machining as cannot be performed with no electrode wear due to the work piece material or machining condition. PL may be set for straight polarity.
  ⊙ Machining to be performed using C800's requires attention to PL, setting.
  ⊙ PL setting in tile machining condition table is based on the electrode side.



PL and polarity

Appendix 1-4 HP: Auxiliary Power Supply:

--Function -

1. To select ON/OFF state of NOW circuit (a circuit for NO electrode Wear)
2. To select ON/OFF state of voltage control circuit (for low/medium voltage control)
3. To select ON/OFF state of current control circuit
   (for high-voltage auxiliary circuit ON/OFF selection and peak current increase)

H P

P — To set function 3.

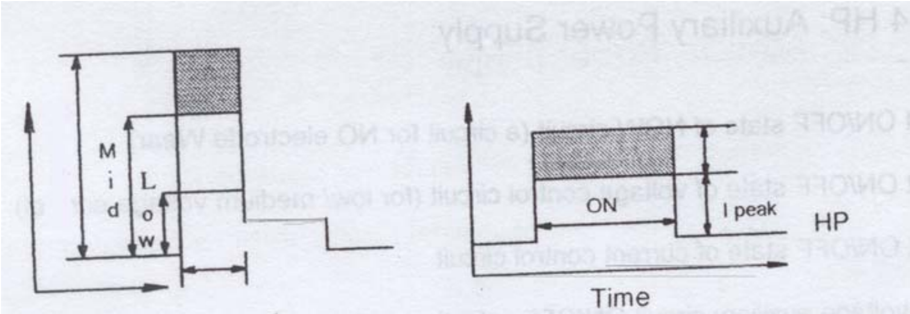
H — To set functions 1 and 2 (See parameter "PP".)

-Type of HP-

Reference value of no-load voltage	Voltage control	NOW circuit		High-voltage auxiliary circuit + peak current
		OFF	ON	
VI=90V V1=120V	Low-voltage circuit set by parameter "V	00	40	OFF
180V	Medium-voltage circuit	10	50	OFF
280V	Low-voltage circuit + high-voltage auxiliary circuit (1)	01~07	41~47	ON P value 0.5 A
280V	Medium-voltage circuit + high-voltage auxiliary circuit (1)	11~17	51~57	ON P value 0.5A
280V	Low-voltage circuit * high-voltage auxiliary circuit (2)	21~27	61~67	On P value 0.5 A
280V	Medium-voltage circuit +high-voltage auxiliary circuit (2)	31~37	71~77	ON P value 0.5 A
		Value of HP		

HP

1 → 0.5A
2 → 1.0A
3 → 1.5A
4 → 2.0A
5 → 2.5A
6 → 3.0A
7 → 3.5A



Change in the no-load voltage causes the over cut to be changed accordingly.

Voltage “High”⟶ EDM spark can occur form a ling distance, causing the over cut to become large.

Voltage “Low”⟶ EDM spark can occur only form a short distance, causing the over cut to become small.

Selection of HP (auxiliary power. supply), its' features and rule of thumb guide for its setting

- Example of standard HP setting

  Roughing (with IP of 8 or above): HP 11

  Finishing (with IP of 7 to 1) ' HP 51

- Example of HP setting for over cut control (as a general rule)

  Roughing (with IP of 4 or above) :HP 00~

  Finishing (with 10mm2 to 100mm2) :HP 40

  (with 100mm2 to 400mm2) :HP 41.

  (with 400mm2 or above) :HP 51

  Machining with less than 10mm2 is categorized as special micro-finishing

Machining Performance Conctroi circuit / Over cut	Machining rate	Chip removal
Low voltage — Small Medium voltage High-voltage — Large Auxiliary power supply	Low ↓ High	Poor ↓ Good

1 .NOW circuit: To allow electrode wear reduction in machining with a low IP value of 7 or below.

2. Voltage control circuit: To change the no-load voltage. An increase in the no-load voltage at the start of discharge allows the EDM spark to occur across the gap more easily, although it leads to increased tendency for the spark current to flow, resulting in higher possibility of secondary discharge.

3. Current control circuit: High voltage auxiliary power supply + peak current control
   An increase in the peak current results in an increase i,,'-~ the surface roughness and a rise in wear on the electrode, especially on its corner section.
   for details con the high-voltage auxiliary circuit refer to "Voltage control circuit"!

HP shows its effect particularly when the IP value is small.

Appendix 1-5 PP ' PIKADEN Pulse Control

P P

①To set PIKADEN pulse control ON / OFF

②To set HP voltage control circuit ON/OFF

①PIKADEN pulse control ON/OFF

[Features]

- To improve the performance of copper-steel machining under condition of no electrode wear with the following advantages:

  (1) Reduction in electrode wear

  (2) Maintenance of EDM spark in stable state and over cut at a constant level

  (3) Protection of electrode against wrinkles on 'its surface, wear on its comers and other defects such as warp caused by heat. ' '

- Greatly useful in large-area work piece machining, rib machining, deep-hole machining and other machining considered to be difficult to perform in the past.

②HP voltage control circuit ON/OFF

[Features]

- To allow the EDM spark to occur across the gap with ease at the start of the machining, thereby ensuring discharge in stable state during the machining. Note, however, that the above gap condition leads to high tendency for the spark current to flow, resulting in high possibility of secondary discharge.

PP setting

PP	Control circuit ON/OFF
00	HP voltage control OFF
01	PIKADEN pulse ON
10	HP voltage control ON
11	HP voltage control + PIKADEN ON

PP

11-max

Standard PP setting (for Cu-St machining) PP10 HP voltage control circuit—ON PIKAGEN pulse control—OFF PP01 can also be used for roughing as its starting condition.

- PIKADEN pulse control can be used under the following condition:
  - ON 08-63 long pulse duration
  - IP 1.5 or above
  - C0

Appendix 1-6 AL: Abnormal Discharge Detection Level Setting

Function: This parameter, designed for the NF power supply system, sets the level at which to detect any abnormal discharge for each machining condition in order to maintain the discharge in optimal state under the machining condition if any change is made in the parameter setting, electrode / work piece material and machining area.

AL setting	Detection sensitivity	Machining rate	Possibility of arcing
0 ↑	High ↑	Low ↑	Low ↑
33	Normally set level		
↓	↓	↓ High	↓ High
63	Low		

Setting range: AL setting

0 ↑

10-20 Machining condition with electrode wear

15-30 Machining condition with low electrode wear

33 20-30 Machining condition with no electrode wear

30-45 Rough cutting with Gr, rough cuttin9 with CuW-WC

↓

◆ The above AL setting slightly varies according to the machining area and other parameter setting,

Appendix 1-7 OC ONCUT Reference Pulse Duration Setting

Function: In the case of machining using an electrode of complex shape, requiring deep cutting or involving a marked change in the machining shape depending on the machining depth under poor flushing condition, this parameter is used to set the ONCUT control level so as to control the possibility of arcing between the electrode and work piece.

This parameter can function in the following ON setting range: 100 - 107 / 8 --63.

Effect

OC setting	IDetection sensitivity	Machining rate	Possibility of arcing
0 1 2 3 4 5 6 7 8 9	Low ↑ ON ~ ON63	ON100 ~ ON107 ↓ High	High ↑ ↓ Low	High ↑ ↓ Low

Appendix 1-8 LD:ON/OFF Control Speed Setting

Function: This parameter sets the ON/OFF/IP control speed according to the AL setting

Effects:

LD setting	Control speed	Possibility of arcing	Acceleration
0			
1	Low	High	High
2	↑	↑	↑
3			
4			
5			
6			
7			
8	↓	↓	↓
9	High	Low	Low

Note: Input LD after AL adjustment

- No electrode wear machining

  ⦿ By definition, "no-wear" is no more than 1% of electrode wear ratio. As a result of EDM machining, debris called "chips" (composed of carbon compounds) is produced, depositing on the electrode surface to form a graphite-like film on it. No electrode wear is assumed to be due to the presence of this film during machining.

- Requirements for no-wear machining

  1) Dielectric fluid Kerosene-based fluid

  2) Work piece material Steel

  3) Electrode material Copper (electrolytic copper, oxygen-free copper, pure copper, etc.)
     Graphite (ED3, IS063, etc.)
     Copper tungsten

  Some electrode materials, even if categorized as copper, graphite and copper tungsten, should be excluded from those for EDM machining of this type due to their quality and composition. (Such electrode materials are often found among those available at low prices)

  Electrodes of iron, brass and zinc alloy are also inappropriate for no-wear machining.

4) Machining conditions As a machining condition for no-wear machining, it is necessary to combine settings of parameters ON / IP l PL in a specific way as described below:

IP	Select settings for relatively low peak current.
ON	Select settings proportional to IP settings
PL	Select reversed polarity with the work piece being negatively poled and the electrode being positively poled.

EDM machining, if performed with an electrode-work piece combination of Cu-St under C 100's machining condition for cutting submerged in dielectric fluid, can achieve an electrode wear ratio of 1% or less, categorized as "No Wear".

- The point in no-wear machining is how to control the way in which the above-mentioned graphite-like film forms on the electrode surface. Slight changes in flushing, work piece material, electrode material, parameter setting and other EDM factors have effects on the no-wear machining performance because such changes influence the production of chips, their removal from the gap, electrode temperature and other factors in the film formation on the electrode surface.
- No-wear machining refers to wear on the electrode on a quantitative basis, button on a geometrical basis.

Influence of ON/PL/IP on electrode wear ratio

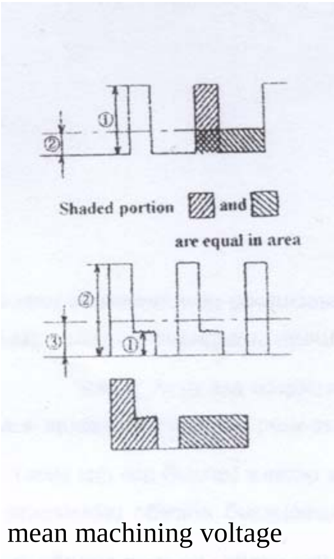
◆ ON 00~23 100~107

~Cu~St~

Electrode wear	Normal wear	Low wear	No wear
ON No.	00~04	05~08 100~107	11~23
Polarity	Positive	Reversed	Reversed
(Electrode) EL / W (Work piece)	- / +	+ / -	+(Small wear) / -(Large wear)
ON/IP IP(1~10) (10~)		ON=IP+6 （ON=16~18）	ON=IP+10(OR 11) (ON=18~20)
Corresponding C code (Cu-St)	C800’s C700’s	C300’s	C100’S C101’S C200’S C102’S

◆ See ON,IP and PL

● Peak current and mean machining current



1) The peak current represents peak value of a Pulse current flowing across the gap when the EDM spark occurs (during the ON time).

2) The mean machining current represents a Current mean value of during a predetermined Time period as indicated on the ammeter The mean machining current, which corresponds to approximately 1/3 of the peak current by .rule of thumb, varies according to the MA / SV / OFF setting and the machining state.

● Machining voltage, no-load voltage and mean machining voltage

1) The machining voltage represents a voltage applied across the gap when the EDM spark occurs (during the ON time).

2) The no-load voltage represents a voltage applied across the gap during the electrode travel before the EDM spark.

3) The mean machining voltage represents a voltage applied across the gap during a predetermined time period as indicated on the voltmeter.

Appendix 2-1 MA: Pulse OFF Duration Control

(1)MA :* *

: Pulse OFF duration control (0-9)

- Setting of 1st digit of MA (pulse OFF duration control)
  The 1st digit of parameter MA is used to set the scale factor by which to increase the standard OFF time Set by parameter OFF.
  Select 0 to 9 for this setting according to the discharge area, machining shape and flushing condition.
  (Parameter MA is generally set at 01 to 03 for roughing and finishing under no electrode wear condition and at 00 to 02 for machining under electrode wear condition.)
- The above MA setting allows the OFF time to be increased by the set scale factor.
- Actual pulse OFF time = OFF (actual time in μ sec) x MA (scale factor from I to 10 times)

Its digit of MA	0	I	2	3	4	5	6	7	8	9
Scale factor	xl	x2	x3	x4	x5	x6	x7	x8	x9	x10

⊙ The MA setting can be changed according to the machining state.

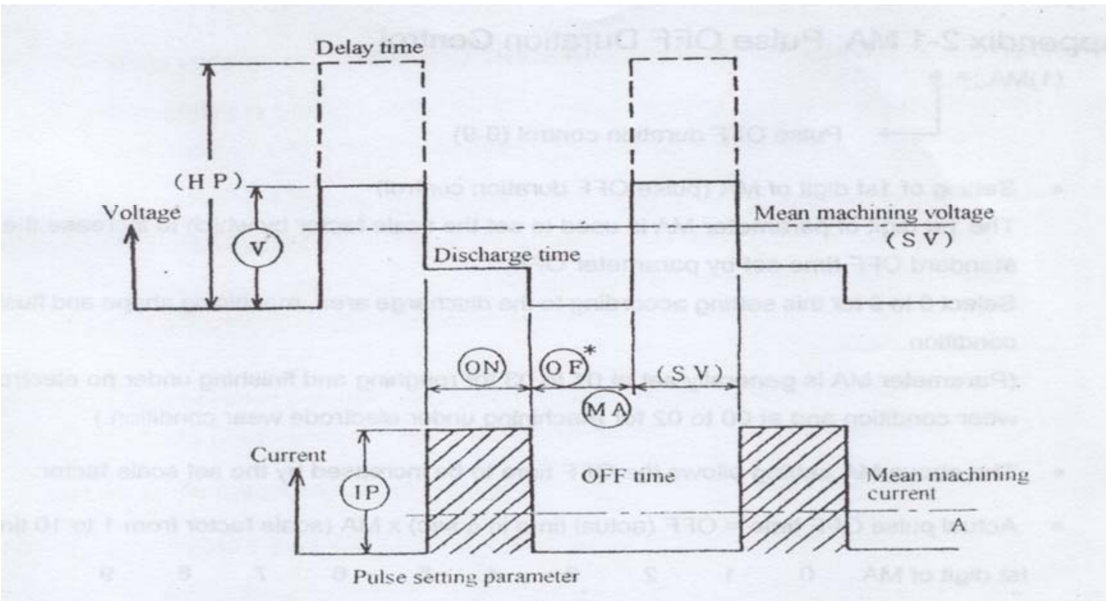
⊙ When the MA setting is increased, the machining rate tends to decrease.

⊙ A fine setting of the pulse OFF time may be achieved by using MAO with OFF set at 30 or above.

⊙ Too short a pulse OFF time setting results in higher possibility of short circuit formation and arcing between the electrode and work piece.

⊙ Machining under normal condition with ON and OFF set at the same value can be performed with MA set at "01".

⊙ Finishing with MA set at a lower value allows reduction in the electrode wear ratio, although resulting in uneven surface finish.

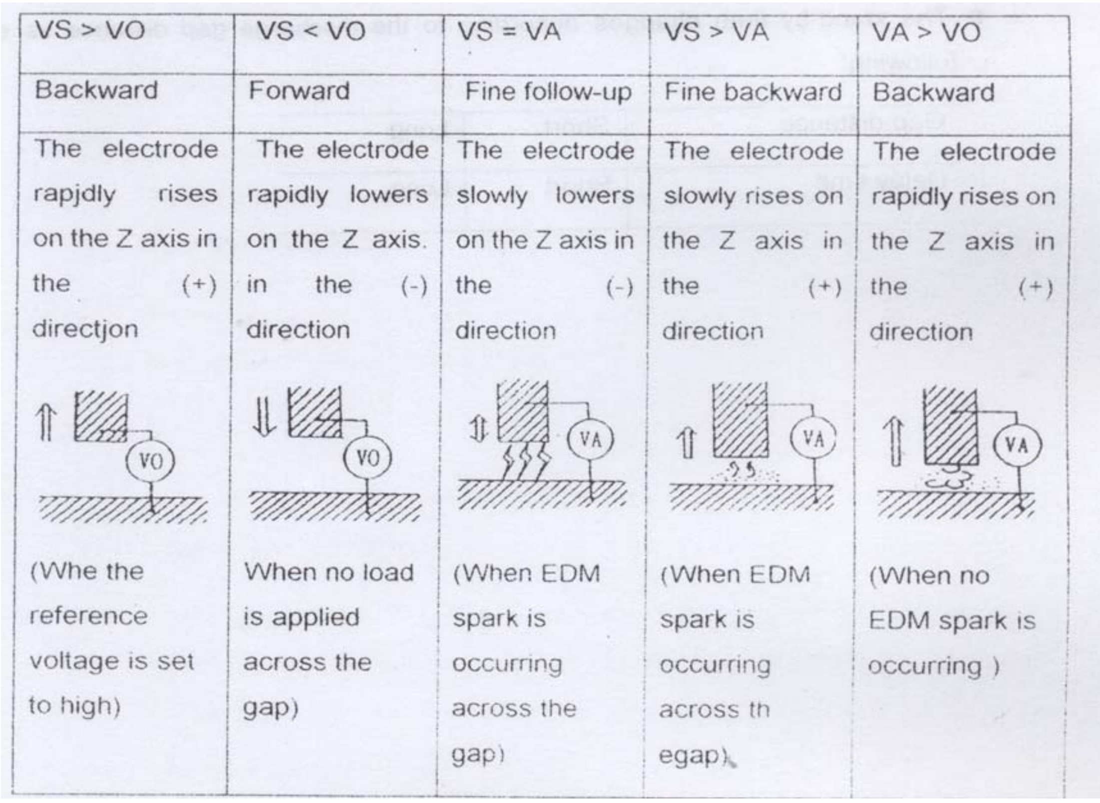


◆ The OFF time changes according to the MA setting.

Appendix 2-2 SV (Servo Reference voltage), Servo Operation and Discharge Waveform

SV (Servo reference voltage): This parameter is used to set the discharge gap between the electrode and work piece to control the mean machining voltage as a reference for senrol follow-up. The parameter, which is set at 5(60V) for machining under normal condition, may be set at a reduced level of 1 to 3 (15 to 35V) for machining under flushing with electrode wear.

- The senrol operation control is based on the change in the voltage across the discharge gap.
  If the voltage across the gap increases above the SV set reference voltage, the electrode moves toward the work piece to narrow the discharge gap - On the other hand, if the gap village decreases below the reference voltage (including when a short circuit occurs across the gap, causing the gap voltage to be reduced to "O"), the electrode moves backward from the work piece, widening the discharge gap



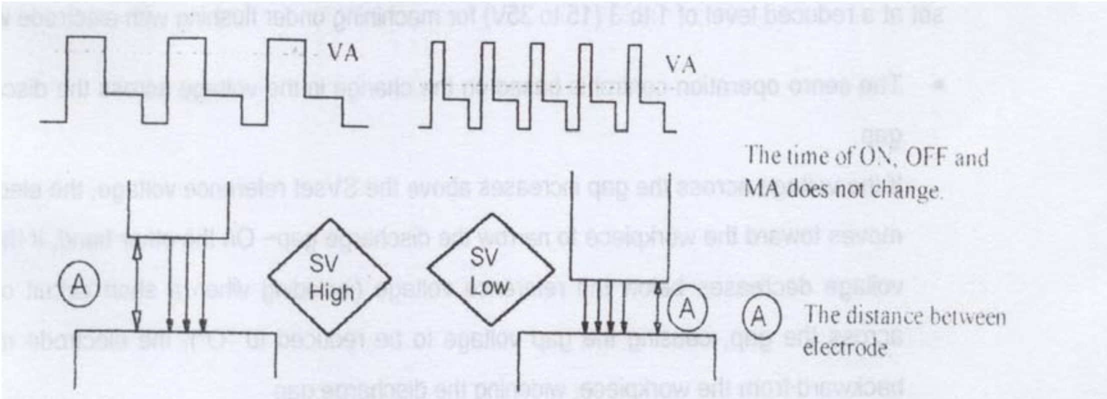
VS > VO	VS < VO	VS = VA	VS > VA	VA > VO
Backward	Forward	Fine follow-up	Fine backward	Backward
The electrode rapjdly rises on the Z axis in the (+) directjon	The electrode rapidly lowers on the Z axis. in the (-) direction	The electrode slowly lowers on the Z axis in the (-) direction	The electrode slowly rises on the Z axis in the (+) direction	The electrode rapidly rises on the Z axis in the (+) direction
(Whe the reference voltage is set to high)	When no load is applied across the gap)	(When EDM spark is occurring across the gap)	(When EDM spark is occurring across th egap)	(When no EDM spark is occurring)

Fig. SV (Servo Reference Voltage) The above chart is based on EDM machining on the Z the axis in the (-) direction.

VO = Open voltage. VA = Mean machining voltage. VS = SV set reference voltage

- The large setting results in an increase in size of discharge gap. In turn, the large discharge gap increases a delay time during which an EDM spark does not occur though voltage is applied across the machining gap.

Gap voltage waveform with large and small SV setting are, respectively, illustrated while ON, OFF and MA setting sure maintained at constant values.



◆ The stand-by time changes according to the discharge gap distance as shown in the following:

Gap distance	Short	Long
Delay time	Short	Long

Appendix 2-3

UP: JUMP operation time setting (UP TIME)

DN: JUMP operation time setting (DN TIME)

◆ JUMP operation: This operation refers to the up/down electrode movement perfumed during the machining operation to increase/decrease the discharge gap to remove the resultant debris called "chips" from the gap and stabilize the machining.

- Parameters "UP"/"DN" are used to set the timing for this JUMP operation to increase/ decrease the discharge gap.
- The JUMP operation mode can be selected by G24 (for high-speed JUMP operation only on the Z axis) and G25 (for JUMP operation on the cutting path).

Example of G24/G25 application

G24 Only applicable for FREE LORAN machining on the Z axis in the (-) direction.

G25 Applicable for any type of machining.

UP To set the time during which the electrode is being raised away from the work piece.

DN To set the time during which the electrode is being lowered and in a position close to the work piece.

- JUMP operation

UP	DN	
0	0-9	NO JUMP TO execute no JUMP operation during machining
0-9	1-9	MANUAL JUMP To execute JUMP operation automatically according to the set timing during machining. (This setting is normally used.)

Rule- of- thum guide for UP/DN setting

Roughing:	G24	DN = UP + 2--3
	G25	DN = UP + 1--2
Finishing:		DN = UR + 0--2

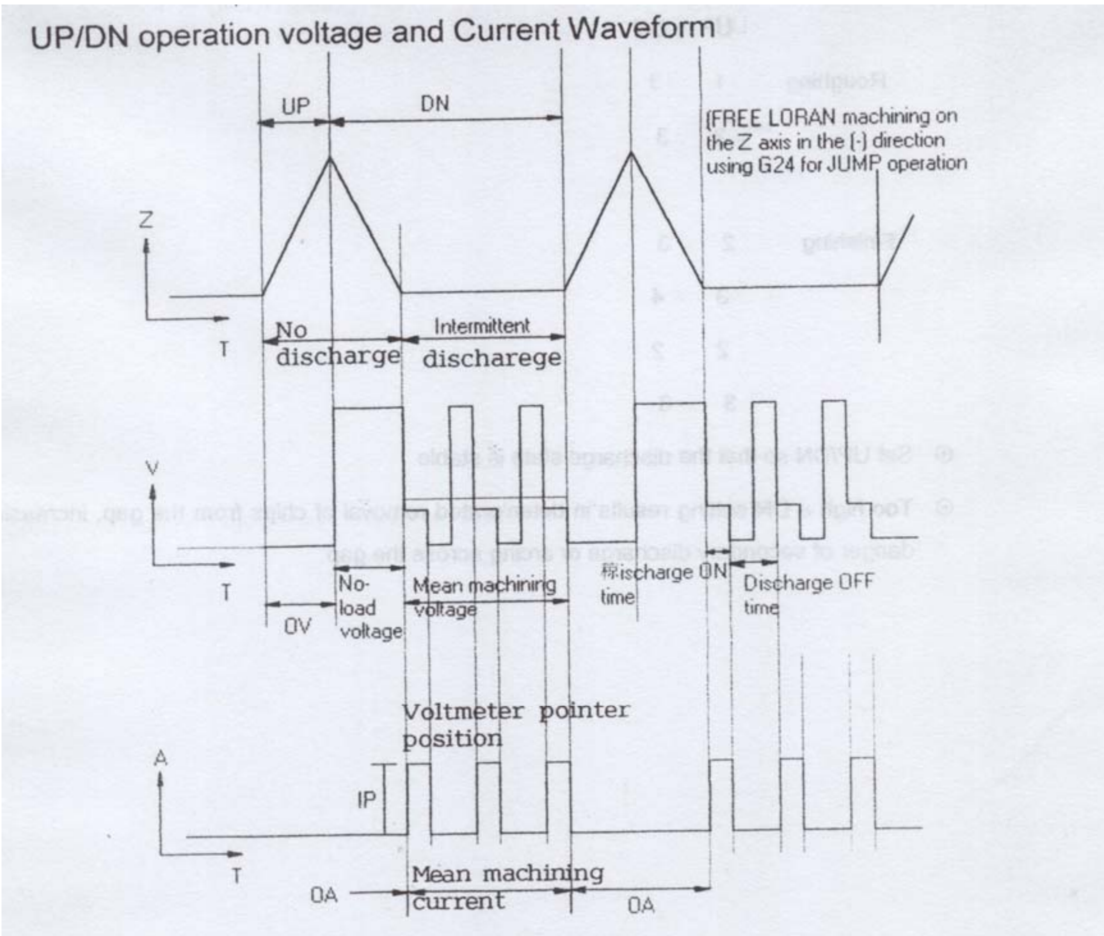
DN setting can e slightly increased if the gap can be flushed properly.

Example of UP/DN setting

	UP	DN
Roughing	1	3
	2	3
Finishing	2	3
	3	4
	2	2
	3	3

⊙ Set UP/DN so that the discharge state is stable.

⊙ Too high a ON setting results in deten'orated removal of chips from the gap, increasing danger of secondary discharge or arcing across the gap.



Ammeter pointer position

(In one discharge circle)

High DN setting -->Frequent repetitions of discharge -,Large volume of chips produced--,High possibility of secondary discharge across the gap

Low DN setting-->infrequent repetitions of discharge-->Small volume of chips produced--,Low possibility of secondary discharge across the gap

Improper removal of chips from the gap requires caution against occurrence of secondary discharge across the gap.

Unstable machining state-->Occurrence of secondary discharge across the gap-->Arcing across the gap

Setting UP at a low level and DN at a high level when the machining state is stable may often cause the machining rate to increase.

Appendix 3-1 List of LORAN patterns

Appendix 3-1 List of LORAN patterns

patterns	plane retraction	OFF					
F	X-Y plane	000	001	002	003	004	005
R	Z-X plane	010	011	012	013	014	015
E	Y-Z plane	020	021	022	023	024	025
E	X-Y plane servo 1	030	031	032	033	034	035
	Z-X plane servo 1	040	041	042	043	044	045
L	Y-Z plane servo 1	050	051	052	053	054	055
N	X-Y plane servo 2	060	061	062	063	064	065
	Z-X plane servo 2	070	071	072	073	074	075
	Y-Z plane servo 2	080	081	082	083	084	085
H	X-Y plane	100	101	102	103	104	105
S	Z-X plane	110	111	112	113	114	115
	Y-Z plane	120	121	122	123	124	125
L	X-Y plane servo 1	130	131	132	133	134	135
N	Z-X plane servo 1	140	141	142	143	144	145
	Y-Z plane servo 1	150	151	152	153	154	155
	X-Y plane servo 2	160	161	162	163	164	165
	Z-X plane servo 2	170	171	172	173	174	175
	Y-Z plane servo 2	180	181	182	183	184	185
A	X-Y plane	200	201	202	203	204	205
X	Z-X plane	210	211	212	213	214	215
I	Y-Z plane	220	221	222	223	224	225
S	X-Y plane servo 1	230	231	232	233	234	235
	Z-X plane servo 1	240	241	242	243	244	245
L	Y-Z plane servo 1	250	251	252	253	254	255
N	X-Y plane servo 2	260	261	262	263	264	265
	Z-X plane servo 2	270	271	272	273	274	275
	Y-Z plane servo 2	280	281	282	283	284	285
T	X-Y plane	300	301	302	303	304	305
H	Z-X plane	310	311	312	313	314	315
I	Y-Z plane	320	321	322	323	324	325
N	X-Y plane servo 1	330	331	332	333	334	335
K	Z-X plane servo 1	340	341	342	343	344	345
	Y-Z plane servo 1	350	351	352	353	354	355
L	X-Y plane servo 2	360	361	362	363	364	365
N	Z-X plane servo 2	370	371	372	373	374	375
	Y-Z plane servo 2	380	381	382	383	384	385

Note) Servo 1: Retracting along path while returning.

Servo 2: Retracting to center while returning.

Note) Servo 1' Retracting along path while returning.

Servo 2: Retracting to center while returning.

Appendix 3-2 QUADRANT LORAN Function

The use of the QUADRANT LORAN function allows the LORAN operation to be performed in a variety of patterns.

This function is designed to divide a plane, on which to perform LORAN operation, into four quadrants so that the pattern of the LORAN operation can be set for each quadrant.

1) QUADRANT LORAN selecting method

The QUADRANT LORAN function can be selected using the 3rd digit (hundreds digit) of parameter "LN".

0: FREE LORAN	5: QUADRANT FREE LORAN
1: HS LORAN	6: QUADRANT HS LORAN
2: LOCK LORAN	7: QUADRANT LOCK LORAN
3: MIRROR LORAN	8: QUADRANT MIRROR LORAN

Even if the 3rd digit of parameter LN is used to select QUADRANT LORAN, its 2nd digit (tens digit) can be used to select the LORAN plane and retraction mode as when the ordinary LORAN function is selected.

The Its digit (units digit) of the parameter is used to set the LORAN pattern for the ordinary LORAN function. Accordingly, the Its digit of parameter LN does not perform its function as long as the 3rd digit of the parameter is used to select QUADRANT LORAN, causing any data input in that digit to be ignored inside the NC unit.

When the QUADRANT LORAN function is selected, the LORAN pattern can be set by such a method as described in the following section (2).

```
LN  *    *    *
    |    |    └── 1st digit: Not related to QUADRANT LORAN
    |    └─────── 2nd digit: LORAN plane and servo state
    └──────────── 3rd digit: To be set at 5 to 7 for QUADRANT LORAN
```

2) QUADRANT LORAN pattern setting

The QUANDRANT LORAN function allows six LORAN patterns to be selected for each quadrant as in the case of the ordinary LORAN function. The LORAN patterns that can be selected for each quadrant and their corresponding pattern Nos. have such a relationship as shown in Table.

The LORAN pattern for ea-h quadrant can be selected by setting4-digit parameter "LF'"
Its digit for the 4th quadrant, 2nd digit for the 3rd quadrant, 3rd digit for the 2nd quadrant and 4th digit for the Its quadrant, in which to input the desired LORAN pattern No. selected from O to 5. It should be noted that the input of 6 or above in any digit as a LORAN pattern

No. causes the LORAN patter for the digit to be regarded as "0".

If the QUADRANT LORAN function is not selected, any data input in this parameter is ignored.

LP * * * *

LORAN pattern for 4th quadrant

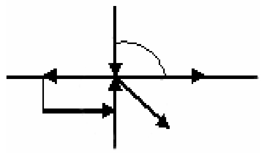
LORAN pattern for 3rd quadrant

LORAN pattern for 2nd quadrant

LORAN pattern for Its quadrant

Example LN500:

LP1024;;

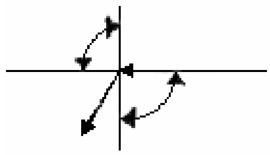


If the parameters LN and LP are set as shown in the above example, the QUADRANT LORAN function is selected to cause the LORAN operation to occur along such a cutting path as illustrated in the drawing at right.

If during the QUADRANT LORAN operation, the end point of the LORAN pattern in the current quadrant is different from the start point of the LORAN pattern in the next quadrant, after the end of the current LORAN operation pattern, such a pattern is automatically inserted as causes the electrode to travel in a straight line from that end point to the start point of the next LORAN operation pattern.

Example LN500;

LP1014;



If the parameters LN and LP are set as shown in the above example the QUADRANT LORAN function is selected to cause the LORAN operation to occur along such a cutting path as illustrated in the

When the path created by the QUADRANT LORAN function forms an open shape that does not pass through the center at all, the pattern to travel to the center will not be inserted.

(3) Parameter LP setting method

The QUADRANT LORAN function can be used with ,ID change made in the format of the machining condition file to maintain corruptibility of its input parameter data with the , other parameter data for ordinary machining.

It should be noted, however, that the machining condition file does not contain LP. a new parameter- designed for QUADRANT LORAN. thus requiring execution of the machining condition "C" to be followed by setting of this parameter LP in order to perform EDM machining using the QUADRANT LOP, AN function. The parameter LP can be set by the following two methods:

1) Input by HF key operation

After loading the desired machining condition from the machining condition file, use the HF key close sponging to "LP" displayed at the bottom of the display to set the parameter.

2) Input by B code

To program the QUADRANT LORAN operation, use B code to set the parameter LP by input of LP ***** or B59*****in the program. (**** indicates four - digit pattern data.)

Example C140;

LNS00 LP4321 ← To execute QUADRANT LORAN
G01 Z-1.0; operation under machining condition
C140 according to LORAN pattern 4321

C120
LN500LP4321 ← When ;any change is made in the
G01 Z-1.04 machining condition, be sure to set
parameter LP again

When any change is made in the machining condition without subsequent resetting of parameter LP, the set data of the parameter cannot be guaranteed.

In the case that the trace created by QUADRANT LORAN, and it has an open shape that doesn't go through the center, the insetting of retract operation pattern is invalid.

Example TN500; ← If input like this, the operation
trace of QUADRANT LORAN will
LP0220 be shown as in the right picture.

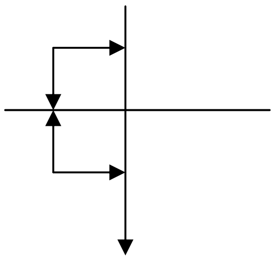
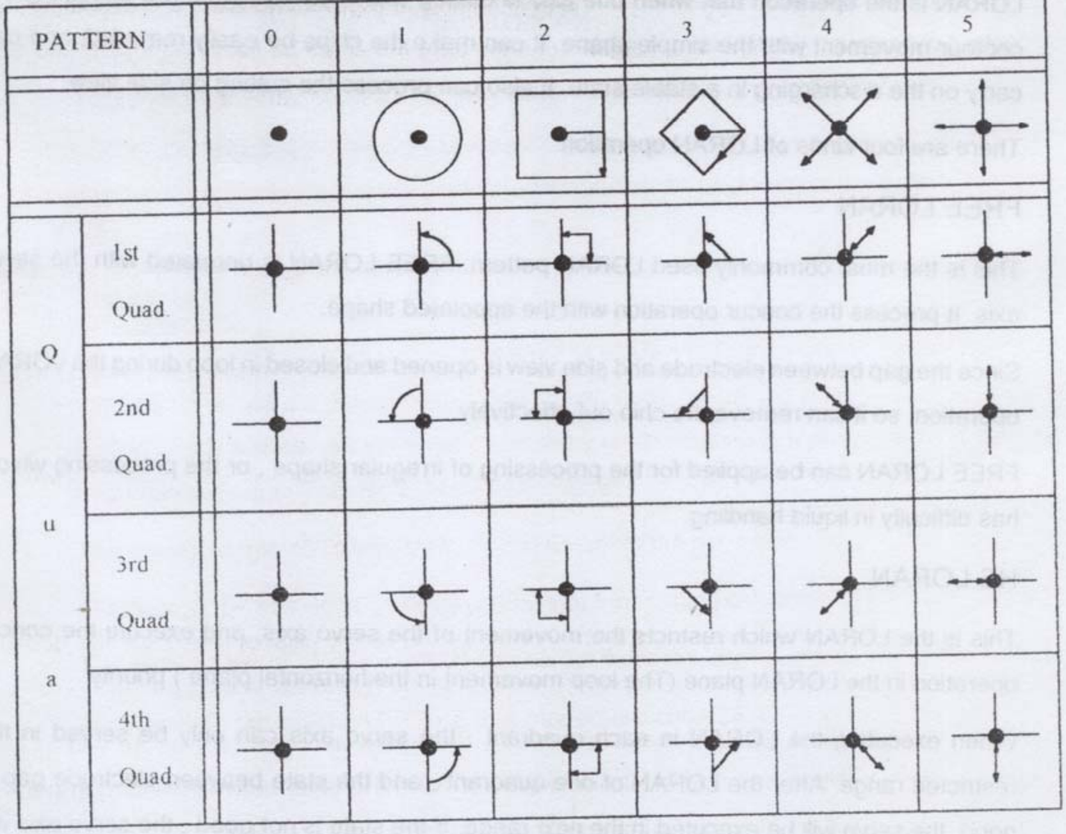


Table of QUADRANT LORAN Pattern



Appendix 3-3 Description of LORAN Function

LORAN is the operation that when one axis is cutting ,the other two axes are executing the contour movement with the simple shape. It can make the chips be easily removed, and can carry on the discharging in a stable state. It also can process the cutting on side view

There are four kinds of LORAN operation:

FREE LORAN

This is the most commonly used LORAN pattern. FREE LORAN is unrelated with the servo axis. It process the concur operation with the appointed shape.

Since the gap between electrode and side view is opened and closed in loop during the LORAN operation, so it can remove the chip out effectively.

FREE LORAN can be applied for the processing of irregular shape, or the processing which has difficulty in liquid handling.

HS LORAN

This is the LORAN which restricts the movement of the servo axis, and execute the concur operation in the LORAN plane (The loop movement in the horizontal, plane.) priority.

When executing the LORAN in each quadrant , the servo axis can only be served in the restricted range. After the LORAN of one quadrant, and the state between electrode gap Js good, the servo will be executed in the next range. If the state is not good, the servo axis will wait or turn back.

HS LORAN is often used for the fine cutting of the side view which is roughly processed. !t can guarantee the finish roughness and the size.

LOCK LORAN

This is the LORAN which stop the processing of the servo axis, and only execute the LORAN operation to enlarge the size by STEP. The LORAN will not be stopped until the cutting reach the appointed STEP.

When one cycle of LOCK LORAN has finished, the state of electrode, gap is good and large enough, the STEP will be enlarged. On the contrary, if the state of electrode gap is not good the STEP will be hold on or shrunk until the bottom remnant is taken off.

LOCK LORAN is used to delete the under cut and wave of side view during rough cutting it can guarantee the roughness.

Since the LOCK LORAN is the special one that stop the servo axis, so the cuttin9 volume o~ servo axis can only be O. To execute the LOCK LORAN, the other cutting method or LORAN pattern must be processed to the start position of cutting.

[Ex]	G54 G90;	-

G01 Z-! 0.0;

LN201 STEP200;

G01 Z-IQ0;	<--Execute LOCK LORAN at Z-10.O

MO2; .	(The cutting volume of Z axis is O)

LOCKLORAN can't be normally processed if the gap between the electrode and bottom is too narrow. If the work and the electrode are touched at the beginning of the cutting, the STEP will not be able to enlarge.

THINK LORAN

This is the LOP, AN that enlarge or shrink the LORAN STEP according to the cutting depth, and the final STEP will be reached when the cutting finish. Since the STEP changes according to cutting depth and cutting state, so it can carry on the cutting in a stable state, it can also can decrease the edge wear for bottom+side cutting.

The enlarge angle of THINK LOP, AN can be set in the set mode.

The final STEP of THINK LORAN can be input in "cutting condition STEP".

The initial STEP of THINK LORAN can be get from the largest one of any of the followings.

- Calculate the initial STEP by Z axis movement and LSEA.
- Calculate the initial STEP by MINIMUM STEP RATE" in [SET DISCHARGE]

[Ex]	G92ZI.0;

LSEA 45.0;	THINK LORAN angle

C100 LN301 STEP200;	THINK LORAN circle pattern last STEP IS 200

G24 G01 Z-3.00 M04;

Display the operation of the

program above.

Start the cutting from Z1.0 to the below of Z axis.

At tat time, the initial STEP is 20gm.(Note 1)

When cutting to Z-2.80 the STEP will be enlarged along the direction of 45 degree. When cutting finished at Z-3.00, the STEP will become 200µm.

- The initial STEP will be the larger one of the following two formula.

1. (Final STEP) X "MINIMUM STEP RATE" of [Set Discharge] / 100

2. (Final STEP) - (Z cutting volume) X tan (enlarge angle)

Now the cutting depth is 4mm, STEP is 2001~m, the angle of THINK LORAN is 45 degree, the MINIMUM STEP RATE is 10%,

1. 200 X 10 / 100 = 20

2. 200 - 4000 X tan45 = (below 0)

So the initial STEP will be 20~zm as formula 1 calculated.

- The enlarge angle of THINK LORAN can be input in "THINK LORAN ANGLE" of [SET DISCHARGE]. the input range is 0 to 45 degree.

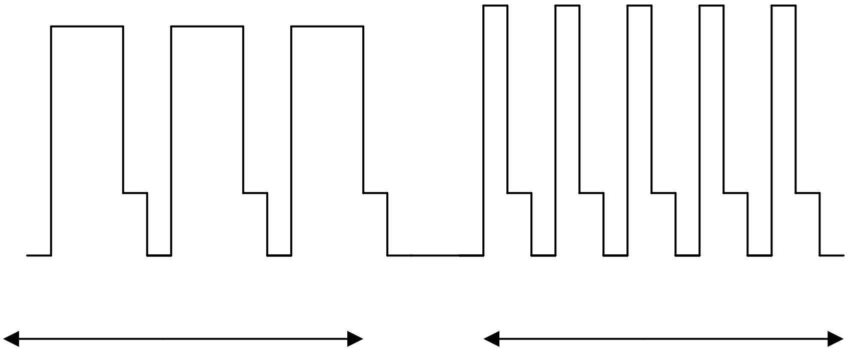
NOTE!

- The enlarge angle of THINK LORAN can also be input in cutting condition LSEA.
- If the program has LSEA, the data set in LESA will be used. The data set in LESA will be valid until the program end (Also include OFF or ERROR).
- THINK LORAN is only for Z axis processing. If multiple axes are used, error will occur.
- Please use the FASTAJC.
- Please select the vertical plane of cutting axis as the LORAN plane. If a wrong plane is selected ,error will occur.
- Set the LORAN SERVO to [NO SERVO], so that the move body and the servo will be synchronic.
- If the condition of LORAN changed during the cutting, the cutting axis will turn back to the start point when the cutting restart.
- If the initial STEP is less than 3~tm. the STEP will be set as 3~.tm. By the way. the final STEP should be set to the data that large than 3μm.

5. Influence of C Code Parameter Change on Machining State

SV setting	0	↔	9
Servo reference voltage	Low	↔	High
Discharge gap	Narrow	↔	Wide
Chip removal	Difficult	↔	Easy
Delay time	Short	↔	Long
No. of repetitions of discharge	Large	↔	Small
Mean machining voltage	Low	↔	High
Mean machining current	Fast	↔	slow
Machining rate	High	↔	Low
Machining state	Unstable	↔	Stable

The following shows the effect of the SV (servo reference vintage) setting on the discharge voltage waveform.



When SV is set "High"　　　　When SV is set "Low

ON Time= (Discharge ON time)

	LONG PULSE		SHORT PULSE
Actual discharge time	Long	↔	Short
Electrode wear ratio	Small	↔	Large
Over cut	Large	↔	S mall
Surface roughness	Rough	↔	Fine
Discharge energy	Large	↔	Small

When the number of repetitions of discharge is the same and the time for one discharge cycle is the same.

- In the case of no-wear machining, the ON time is determined by the IP setting. Too large a ON time setting causes the discharge state to become unstable, resulting in arcing between the electrode and work piece.

  → with failure to maintain the discharge energy at a uniform level

OFF Time x MA(Discharge OFF time)

Actual discharge OFF time	Long	↔	Short
Machining rate	Low	↔	High
Electrode wear ratio	Large	↔	Small (possibly)
Over cut	Small	↔	Large (possibly)
Surface roughness	Little change		

- The electrode wear ratio and over cut are largely dependent on the machining state, while they can be regarded as little affected by the OFF/MA setting.
- Setting the discharge OFF time extremely short makes the recovery of insulation across the gap difficult, resulting in high possibility of arcing across the gap.
- The machining rate is dependent on the number of repetitions of discharge, which increases with decreasing setting of the OFF time. (This causes no change in the discharge energy.)

IP=Peak current

IP setting	Small	↔	Large
Peak current	Small	↔	Large
Discharge energy	Small	↔	large
Machining rate	Small	↔	Large
Over cut	Small	↔	Large
Surface roughness	Fine	↔	Rough

CHAPTER 2. BASICS FOR EDM MACHINING CONDITION SETTLING

1, NC EDM Spark Discharge

"Electrical discharge machining (EDM)" is an electrical machining method in which EDM sparks are continuously produced in an insulating fluid to apply their corrosive action to a conductor (mainly metal work piece) for drilling and cutting into a desired shape. Discharge occurring as a natural phenomenon ranges so widely and diversely that it is assumed to be complex and difficult to deal with academically. In contrast, discharge generated from our EDM is considered to progress undergoing repetition of such changes as described below.

1) No-load DC voltage is applied across two electrodes (tool electrode and workpiece) allowed to face each other through a dielectric fluid (kerosene type petroleum or demonized water). (The "MARK" series are designed so that the no-load voltage and gap detection voltage are selected by parameters V and HP settings.)

2) If the gap between the two electrodes is too large, the servo operation on the Z or X/Y axis will occur to reduce the gap automatically with consequent breakdown of insulation across the gap, causing EDM sparks to occur across the gap. The gap achieved to generate such discharge sparks is specifically referred to as a "Discharge Gap", which is 2 to 5 -Lm for fine discharge of a small quantity of electrical energy and several tens of mill microns for discharge of a large quantity of electrical energy.

3) In a rnoment after the occurrence of the EDM spark across the gap, it is subjected to electron avalanche, followed by a high-temperature/ high-pressure fire column called "Discharge Column" for its bridging, which is to last for a specific period ot: time. The power supply circuit is provided to control this period of time within a proper range of several - sec to limes, during which time the base of the discharge column reaches a high temperature of 3000"C or above, causing the metal structure to be melted with its ionization occurring on a partial basis.

4) As a result of the above, the insulating quid across the gap will explosively vaporizes and expands, causing a part of the molten metal to be flied out with resultant formation of uneven craters on the EDM d surface. When the molten metal forms a mushroom-shaped protruding portion, the next discharge column will occur On tills portion. The explored insulatin9 fluid, while vaporizing, will turn into a verity of carbides, pad of which is to be melted into tar-like substances before being discharged from the gap.

5) Meta! ions and gas tar-like substances produced by -DM sparks will diffuse, causing the gap to recover its insulation, which, in turn, allows voltage to be applied across the gap to generate the nary discharge across it. The pits produced as a result of EDM. when just after formed, are of saucer shape like craters on the moon with their surroundings elevated. As

EDM progresses, such pits will be produced with one placed on top of another to form a roughness on the EDM'd surface.

The timing required for recovery of insulation across the gap after the action of a discharge column across it is at last about twice the discharge time. In the case of a high-current pulse with a short discharge time, the required timing for such recovery is approximately as long as the discharge time. In either case, however, the timing is similarly short on the order of is sec to msec. Accordingly, the number of repetitions of the discharge/insulation recovery across the gap in a unit period of time, which is referred to as "Discharge Frequency", extends from several hundreds of Hz to several KHz (See Fig.l-1)

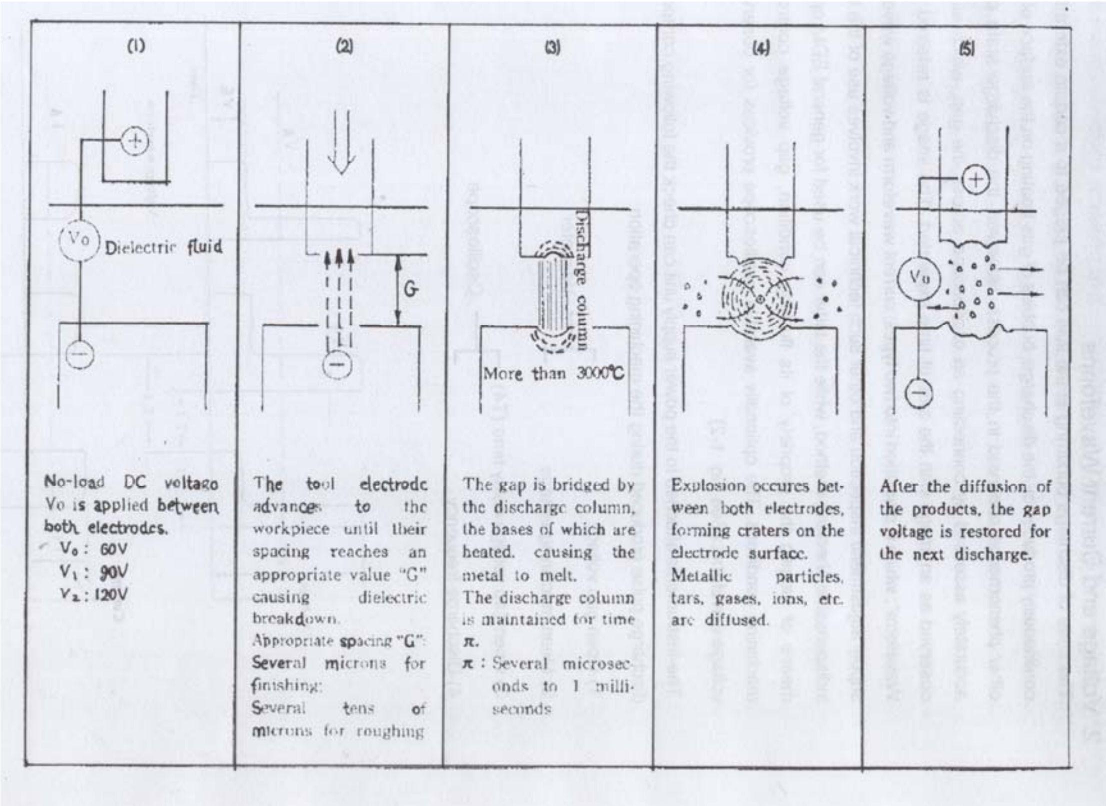


Fig 1-1 Electric discharge phenomena

2. Voltage and Current Wavefonns

The state of discharge occurring in the fluid can be judged to a certain extent by the sound continuously produced by the discharge, bubbles of gas floating on the surface of the fluid and other phenornenna observed in the process. However, the discharge state can be more accurately assessed by connecting an oscilloscope across the gap, which allows it to be observed as an image with the axis of time expanded. The image is referred to as "Pulse Waveform", which is classified into two types: current waveform and voltage waveform. Power supply adjustment/inspection and other such technical work involves use of the former as an indispensable checking method, while the latter can be used for general EDM operation as a means of judging the propriety of its flushing 'condition, gap voltage control and other machining conditions. The optionally available oscilloscope provides for observation of the voltage waveform. (See Fig. 1-2)

The-instruments attached to the power supply unit can check the following components of the discharge pulse produced during the machining operation:

1) Open gap voltage — Volmeter
2) Mean machining voltage — Volmeter
3) Open gap voltage delay time (T4) — Oscilloscope
4) Discharge frequency — Oscilloscope

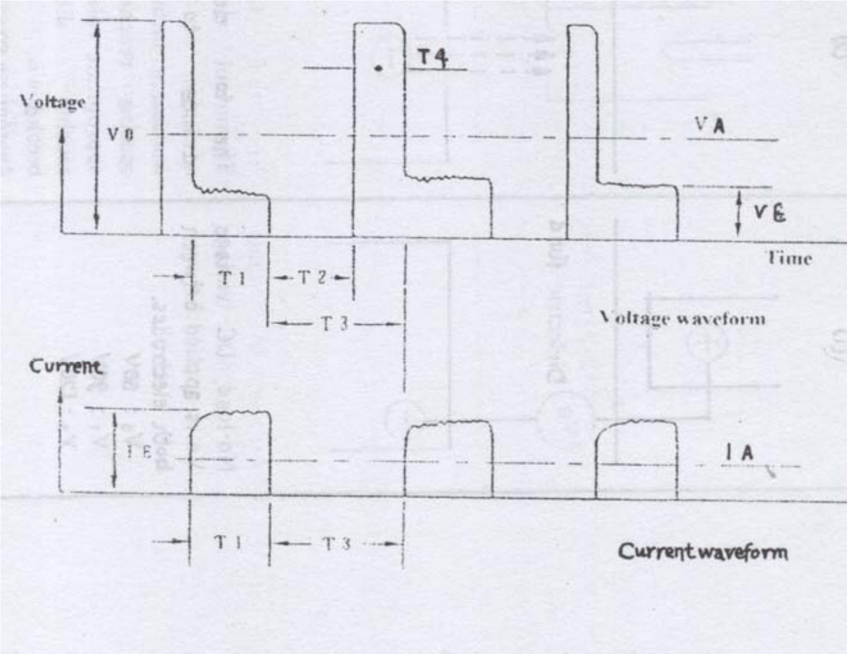


Fig. 1-2 Voltage and Current Waveforms

The voltage waveform produced on the oscillograph as an image of the discharge state allows its assessment to be made on the following points:

1) No-load voltage "VO" and its stand-by time "T4"

2) Change in voltage across the gap during discharge

3) Mean ratio of discharge ON time "%1" to discharge OFF time "T3" and change in the discharge frequency

The abbreviations used in the above chart stand for the following:

VO: Open gap voltage VE: Discharge voltage VA: Mean machining voltage

IE: Discharge peak current IA: Mean machining current

T1 :Pulse ON time T3:Discharge OFF time

T2:Pulse OFF time T4:No-load voltage delay time

3. Open Gap Voltage and Mean Machining Voltage

The no-load voltage is a voltage applied across the gap before the spark current flows for discharge or when AJC or other operation occurs for separation of the discharge gap as indicated on the voltmeter and oscilloscope. It is basically classified into the following three types according to the circuit system selected by parameter "HP".

1)Low voltage — When HP=00/HP40 is selected to produce discharge circuit with no-load voltage of V=I 90VN=2 120V.
Actually, however, the above voltage 30V is applied across the gap.

2)Medium voltage — When HP = 10 / HP = 50 is selected to produce control circuit with no-load voltage of 180V.

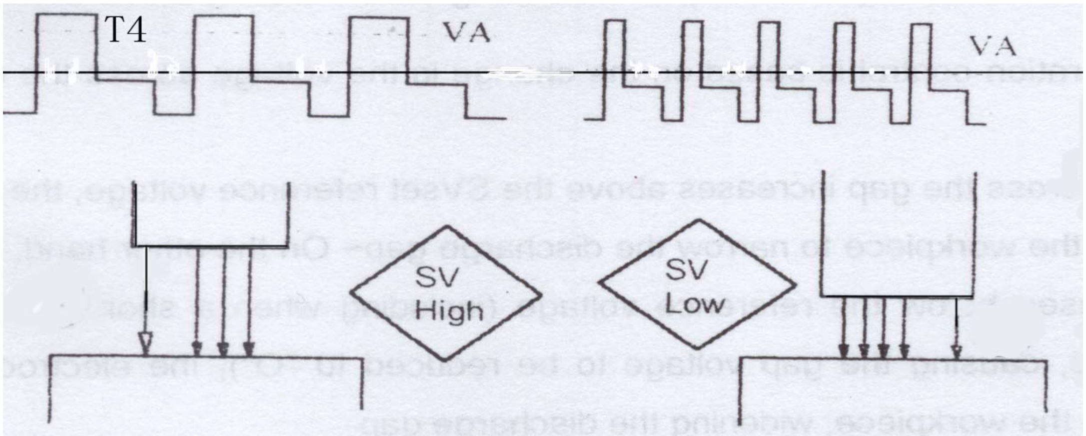
3)High voltage — When HP = 11-17/any other setting other than in 0 and 0 above is selected to produce high-voltage circuit with no-load voltage of 280.

In the case of EDM machining with AJC UUMP operation) inserted during the process to cause the reciprocating motion of the electrode across the gap, the indication of the open gap voltage for each such jump represents proper discharge of the EDM debris from the gap with smooth recovery of insulation across the gap.

The pulse discharge voltage differs from pulse to pulse, ranging from 25 to 30V, which is far below the no-load voltage. An increase in the setting of parameter SV, which serves to set the reference voltage for automatic control of the distance across the gap, in the direction of O -- 9 causes the discharge stand-by time "T4" to be extended with a rise in the mean machining voltage "VA".

The above indicates an increase in the distance across the gap with a decrease in the discharge frequency.

Setting parameter SV (reference voltage) at a lower level causes T4 to be shortened with a decrease in the mean Inclining voltage. This Inanes a descries in the distance across the gap with a rise in the discharge frequency. (See Fig. 1-3.)



The gap is wide and the discharge frequency is low, resulting in low possibility of the gap clogging with debris caused by EDM.

The gap is narrow and the discharge frequency is high, resulting in high possibility of the gap clogging with debris caused by EDM.

Fig. 1-3 Mean Machining Voltage SV and Discharge Frequency

4. Pulse Energey and Mean Machining Current

The relationship between the current waveform and the machining performance haracteristics, which will be separately described in more detail, is, in principle, as follows:

IE (peak current) xT (pulse ON time) is proportional to the discharge energy available from each pulse, influencing the roughness of the EDM's surface, which becomes rough if the above value is large and fine if it is small as summarized in the following chart:

IExTI	Large	Rough surface	Roughing	High machining efficiency
IExTI	Small	Fine surface	Finishing	Low machining efficiency

The peak current IE is set by combination of parameters IP (No. of Tr circuits) and V (no-load voltage). The mean machining current lA indicated on the ammeter during the machining with continuous discharge is given by multiplying IE by the ratio of the discharge ON time to the discharge OFF time as represented by the following expression:

$$\text{lA (Mean machining cunent)} = \text{IE (Peak current)} \times \frac{\text{T1 (Pulse ON time)}}{\text{T1 + T3 (Discharge OFF time)}}$$

The discharge OFF time is given by pulse OFF time "T2" added to stand-by time "T4".
The shorter the discharge OFF time, the higher the discharge frequency (which represents the number of repetitions of discharge in a given time) with an expected increase in the machining efficiency under a given pulse energy condition, although the efficiency increase is limited.

In the case of EDM machining of steel material with a copper electrode under no electrode wear condition, the dischage OFF time required for recovery of insulation across the gap is normally about twice the pulse ON time. Accordingly, the machining current lA indicates about 1/3 of the peak current IE. In the case of NF25, setting of IP 15.5 and V = 2 produces the maximum peak current of 62.7A, which means that the mean machining current exceeds 40A. For actual cavity die machining, however, the NF series is mostly used with the peak current of 30A and the machining current of 10A or below.
In addition, the NF series id generally operated with the longest time required for finishing with the machining current of 2A or below.

NF model	Maximum current	Maximum IP
NF 25	25	15.5
NF 40	40	31.5
NF 80	80	63.5

CNC EDM

Electric Discharge Condition Parameter List

DIMON BEIJING CNC TECHNOLOGY CO., LTD.

2017

C100 Machining Condition File
Cu－St（No-Wear Machining A）

		Electric Discharge Condition Parameters											Machining Condition		Machining Performance					
																		Overcut（μ）		
	NO.	ON	OFF	MA	IP	SV	PL	V	HP	PP	C	S	Mean Voltage/V	Mean Current/A	Machining Rate g / min mm^3 / min	Surface Roughness μRmax	Electrode Wear Ratio E/W*100 %	α	β	γ
1	C100	011	011	01	001.0	03	+	01	040	10	00	02	40	1	0.004 0.5	6	1	10	30	50
2	C110	012	012	01	002.0	03	+	01	040	10	00	02	60	2	0.020 2.6	12	0.8	15	60	80
3	C120	014	014	01	003.0	04	+	01	050	10	00	02	65	4	0.045 5.6	17	0.7	30	70	90
4	C130	015	015	01	004.0	05	+	01	051	10	00	02	70	6	0.100 13	26	0.4	60	90	110
5	C140	016	016	01	005.0	05	+	01	051	10	00	02	80	7	0.160 21	32	0.2	70	110	130
6	C150	017	017	01	006.0	05	+	01	051	10	00	02	75	8	0.220 28	36	0.1	80	120	160
7	C160	018	018	01	007.0	05	+	01	051	10	00	02	75	10	0.260 33	40	0.1	90	160	200
8	C170	019	019	01	010.0	05	+	01	011	10	00	02	75	14	0.600 78	50	0.2	120	210	250
9	C180	020	020	01	015.0	05	+	01	011	10	00	02	80	21	1.000 128	65	0.2	140	270	310
10	C190	021	021	01	020.0	05	+	01	010	10	00	02	80	25	1.200 156	75	0.2	160	300	360
For SV, MA, UP, DN, make proper adjustments																				

C200 Machining Condition File
Cu—St(No-Wear Machining B)

		Electric Discharge Condition Parameters											Machining Condition		Machining Performance					
	NO.	ON	OFF	MA	IP	SV	PL	V	HP	PP	C	S	Mean Voltage/V	Mean Current/A	Machining Rate g / min mm^3 / min	Surface Roughness μRmax	Electrode Wear Ratio E/W*100%	Overcut（μ） α	β	γ
1	C200	011	011	01	001.0	05	+	01	051	10	00	02	40	1.5	0.006 0.75	8	5	20	50	70
2	C210	012	012	01	002.0	05	+	01	051	10	00	02	60	3	0.025 3.2	13	1.7	30	70	90
3	C220	013	013	01	003.0	05	+	01	051	10	00	02	65	4	0.060 8	17	1.0	35	80	100
4	C230	014	014	01	004.0	05	+	01	011	10	00	02	65	6	0.100 13	24	0.7	40	90	115
5	C240	015	015	01	005.0	05	+	01	011	10	00	02	80	7	0.170 22	30	0.6	50	100	130
6	C250	016	016	01	006.0	05	+	01	011	10	00	02	90	8	0.230 30	35	0.5	60	120	140
7	C260	017	017	01	007.0	05	+	01	011	10	00	02	95	8	0.300 38	40	0.5	70	130	170
8	C270	018	018	01	010.0	05	+	01	011	10	00	02	100	11	0.560 72	45	0.8	90	190	220
9	C280	019	019	01	012.0	05	+	01	011	10	00	02	110	14	0.740 91	50	0.8	120	210	260
10	C290	019	019	01	015.0	05	+	01	011	10	00	02	110	16	0.900 115	55	0.8	170	250	320
For SV, MA, UP, DN, make proper adjustments																				

C300 Machining Condition File

Cu—St(Low-Wear Machining)

		Electric Discharge Condition Parameters											Machining Condition		Machining Performance					
	NO.	ON	OFF	MA	IP	SV	PL	V	HP	PP	C	S	Mean Voltage/V	Mean Current/A	Machining Rate g / min mm^3 / min	Surface Roughness μRmax	Electrode Wear Ratio E/W*100%	Overcut（μ） α	β	γ
1	C300	005	032	00	001.0	05	+	01	052	10	00	02	65	1	0.007 0.9	7	4	20	40	60
2	C310	008	008	00	001.0	05	+	01	051	10	00	02	70	1	0.005 0.7	6	3	20	45	60
3	C320	008	008	00	002.0	05	+	01	051	10	00	02	60	2	0.022 2.8	11	2	30	50	80
4	C330	009	009	01	003.0	05	+	01	051	10	00	02	70	2	0.046 5.9	15	2	35	55	85
5	C340	010	010	01	004.0	05	+	01	051	10	00	02	80	3.5	0.100 12	18	1.4	40	60	90
6	C350	011	011	01	005.0	05	+	01	011	10	00	02	95	4.5	0.140 18	24	2	45	80	100
7	C360	012	012	01	007.0	05	+	01	011	10	00	02	85	7.5	0.280 36	35	2	60	100	120
8	C370	015	015	01	010.0	05	+	01	011	10	00	02	110	11	0.500 65	48	3	85	135	240
9	C380	016	016	01	015.0	05	+	01	011	10	00	02	90	17	0.940 120	55	3	110	180	240
10	C390	018	018	01	023.0	05	+	01	011	10	00	02	100	24	1.800 230	70	3	190	240	320
For SV, MA, UP, DN, make proper adjustments																				

C400 Machining Condition File

Gr—Cu(Low-Wear Machining A【ED-4】)

		Electric Discharge Condition Parameters											Machining Condition		Machining Performance					
	NO.	ON	OFF	MA	IP	SV	PL	V	HP	PP	C	S	Mean Voltage/V	Mean Current/A	Machining Rate g / min mm^3 / min	Surface Roughness μRmax	Electrode Wear Ratio E/W*100%	Overcut（μ） α	β	γ
1	C400	005	034	01	001.5	05	+	02	000	00	00	02	50	1.5	0.015 2	7	12	10	20	35
2	C410	010	010	01	001.5	05	+	02	000	00	00	02	50	1.5	0.005 0.7	9	5	15	40	80
3	C420	010	010	01	002.5	05	+	02	000	00	00	02	50	2.5	0.038 5	14	2	30	50	85
4	C430	010	010	01	003.5	05	+	02	000	00	00	02	50	4	0.080 10	22	1.5	50	60	90
5	C440	011	011	02	005.5	05	+	02	000	00	00	02	50	6	0.160 20	36	0.6	60	95	130
6	C450	012	012	02	007.5	05	+	02	000	00	00	02	50	10	0.400 50	44	0.4	70	105	140
7	C460	013	013	02	012.0	05	+	02	000	00	00	02	50	15	0.650 85	55	0.1	90	130	165
8	C470	014	014	02	018.0	05	+	02	000	00	00	02	60	24	1.200 150	65	0.1	100	150	210
9	C480	014	014	02	029.0	05	+	02	000	00	00	02	70	34	2.200 280	75	0	140	200	245
10	C490	014	014	02	031.0	05	+	02	000	00	00	02	70	40	3.800 490	90	0.1	150	210	260
For SV, MA, UP, DN, make proper adjustments																				

C500 Machining Condition File
Gr—St(Low-Wear Machining B【ED-3】)

		Electric Discharge Condition Parameters											Machining Condition		Machining Performance					
	NO.	ON	OFF	MA	IP	SV	PL	V	HP	PP	C	S	Mean Voltage/V	Mean Current/A	Machining Rate g / min mm^3 / min	Surface Roughness μ Rmax	Electrode Wear Ratio E/W*100%	Overcut（μ） α	β	γ
1	C500	008	008	01	001.5	05	+	02	000	00	00	02	60	1.5	0.008 1.0	8	15	10	30	50
2	C510	008	008	01	002.5	05	+	02	000	00	00	02	50	2	0.047 6	13	10	20	40	60
3	C520	008	008	01	003.5	05	+	02	000	00	00	02	65	3	0.090 12	16	6	25	60	80
4	C530	010	010	01	005.5	05	+	02	000	00	00	02	70	6	0.210 28	25	4	35	70	90
5	C540	015	015	02	005.5	05	+	02	000	00	00	02	55	10	0.250 32	35	0.1	50	80	100
6	C550	015	015	02	007.5	05	+	02	000	00	00	02	55	13	0.450 57	45	0.1	80	95	120
7	C560	016	016	02	012.0	05	+	02	000	00	00	02	60	18	0.700 90	55	0.1	100	130	170
8	C570	016	016	02	018.0	05	+	02	000	00	00	02	70	22	1.500 190	60	0.2	120	150	180
9	C580	016	016	02	029.0	05	+	02	000	00	00	02	70	35	2.700 350	80	0.1	140	190	230
10	C590	016	016	02	031.0	05	+	02	000	00	00	02	75	42	0.400 510	95	0.1	160	220	250
For SV, MA, UP, DN, make proper adjustments																				

C600 Machining Condition File
Gr－St(Proper-Wear【ED-3】)

		Electric Discharge Condition Parameters											Machining Condition		Machining Performance					
	NO.	ON	OFF	MA	IP	SV	PL	V	HP	PP	C	S	Mean Voltage/V	Mean Current/A	Machining Rate g / min mm^3 / min	Surface Roughness μRmax	Electrode Wear Ratio E/W*100%	Overcut（μ） α	β	γ
1	C600	001	030	01	001.5	03	−	02	032	10	04	02	60	−	0.003 0.4	8	45	5	10	15
2	C610	002	030	01	002.5	03	−	02	031	10	05	02	50	1.5	0.030 4.4	9	34	5	10	20
3	C620	002	030	01	005.5	03	−	02	031	10	05	02	50	2	0.040 5.1	10	29	5	15	25
4	C630	002	031	01	012.0	03	−	02	031	10	05	02	40	4	0.080 10.6	11	27	5	15	25
5	C640	002	031	01	018.0	03	−	02	031	10	06	02	40	5.5	0.090 10.9	11	27	10	20	30
6	C650	003	031	01	018.0	03	−	02	031	10	06	02	50	7	0.200 25.4	20	24	10	35	60
7	C660	005	034	01	018.0	03	−	02	031	10	06	02	50	10	0.600 77.9	30	19	20	55	85
8	C670	006	034	01	018.0	03	−	02	031	10	07	02	50	14.5	1.100 137.1	32	16	30	65	100
9	C680	006	034	01	029.0	03	−	02	031	10	07	02	50	20	1.500 191.6	35	16	40	75	115
10	C690	007	035	01	031.0	03	−	02	031	10	08	02	60	28	2.200 286.2	40	15	50	100	140
For SV, MA, UP, DN, make proper adjustments																				

C700 Machining Condition File

CuW—WC(G2)A(Proper-Wear A)

With minimum SV and mean machining voltage is:

		Electric Discharge Condition Parameters											Machining Condition		Machining Performance					
	NO.	ON	OFF	MA	IP	SV	PL	V	HP	PP	C	S	Mean Voltage/V	Mean Current/A	Machining Rate g / min mm³ / min	Surface Roughness μ Rmax	Electrode Wear Ratio E/W*100%	Overcut（μ）α	β	γ
1	C700	001	031	00	001.5	03	–	02	000	10	01	02	40	1	0.010 0.7	4	13	5	10	15
2	C710	001	031	00	002.5	03	–	02	000	10	02	02	45	2	0.026 1.8	5	14	5	10	15
3	C720	002	031	00	003.5	03	–	02	000	10	03	02	35	4	0.070 4.8	6	15	10	15	25
4	C730	002	031	00	005.5	03	–	02	000	10	04	02	25	6.5	0.200 14	7	16	15	20	30
5	C740	002	031	01	007.5	03	–	02	000	10	05	02	20	7.5	0.230 16	9	16	20	25	35
6	C750	002	031	01	012.0	03	–	02	000	10	06	02	20	9	0.260 18	10	17	25	30	40
7	C760	002	031	01	015.0	03	–	02	000	10	07	02	20	11	0.430 30	11	18	30	40	50
8	C770	003	031	00	018.0	03	–	02	000	10	07	02	20	12	0.500 35	12	18	35	45	60
9	C780	004	032	01	029.0	03	–	02	000	10	08	02	20	18	0.580 40	14	22	45	55	65
10	C790	004	032	01	031.0	03	–	02	000	10	08	02	20	20	0.720 50	15	24	50	60	70

（1）For SV, MA, UP, DN, make proper adjustments;（2）Working fluid: VIN

C700 Machining Condition File

CuW一WC(G2)B(Proper-Wear B)

With SV mean machining voltage of 40V:

		Electric Discharge Condition Parameters											Machining Condition		Machining Performance					
	NO.	ON	OFF	MA	IP	SV	PL	V	HP	PP	C	S	Mean Voltage/V	Mean Current/A	Machining Rate g / min mm^3 / min	Surface Roughness μ Rmax	Electrode Wear Ratio E/W*100%	Overcut（μ）α	β	γ
1	C700	001	031	00	001.5	03	－	02	000	10	01	02	65	1	0.003 0.2	4	13	5	10	15
2	C710	001	031	00	002.5	03	－	02	000	10	02	02	55	1.5	0.013 0.9	5	14	5	10	15
3	C720	002	031	00	003.5	03	－	02	000	10	03	02	50	3	0.050 3.5	6	15	10	15	25
4	C730	002	031	00	005.5	03	－	02	000	10	04	02	50	4.5	0.065 4.5	7	16	15	20	30
5	C740	002	031	01	007.5	03	－	02	000	10	05	02	50	5	0.087 6	9	16	20	25	35
6	C750	002	031	01	012.0	03	－	02	000	10	06	02	40	5.5	0.120 8	10	17	25	30	40
7	C760	002	031	01	015.0	03	－	02	000	10	07	02	50	6	0.150 10	11	18	30	35	45
8	C770	003	031	00	018.0	03	－	02	000	10	07	02	40	6.5	0.180 12	12	18	30	40	50
9	C780	004	032	01	029.0	03	－	02	000	10	08	02	40	11	0.300 21	14	22	35	45	55
10	C790	004	032	01	031.0	03	－	02	000	10	08	02	40	13.5	0.340 23	15	24	40	50	70

（1）For SV, MA, UP, DN, make proper adjustments;（2）Working fluid: VIN

C800 Machining Condition File
Cu—St(Proper-Wear)

		Electric Discharge Condition Parameters											Machining Condition		Machining Performance					
	NO.	ON	OFF	MA	IP	SV	PL	V	HP	PP	C	S	Mean Voltage/V	Mean Current/A	Machining Rate g / min mm^3 / min	Surface Roughness μ Rmax	Electrode Wear Ratio E/W*100%	Overcut（μ） α	β	γ
1	C800	001	030	03	000.0	05	−	01	010	10	01	03	90	—	0.0003 0.044	2.2	35	10	15	20
2	C810	001	030	03	000.0	05	−	01	012	10	01	03	90	—	0.0005 0.064	2.6	37	10	15	20
3	C820	001	030	03	000.0	05	−	01	015	10	02	03	90	—	0.0014 0.18	3.2	40	10	15	20
4	C830	001	030	03	000.0	05	−	01	017	10	03	03	90	—	0.0015 0.19	3.2	40	10	15	20
5	C840	002	031	03	005.0	05	−	01	012	10	04	03	85	0.5	0.0015 0.19	4	45	10	15	20
6	C850	002	031	03	012.0	05	−	01	012	10	06	03	80	1.5	0.006 0.74	5	34	15	20	30
7	C860	003	031	03	015.0	05	−	01	011	10	07	03	85	2	0.023 2.92	10	31	15	25	35
8	C870	003	031	03	023.0	05	−	01	011	10	08	03	85	3	0.061 7.87	14	30	20	35	50
9	C880	003	031	03	031.0	05	−	01	011	10	09	03	85	4.5	0.120 16.02	18	25	35	50	70
10	C890	003	031	03	031.0	05	−	02	011	10	09	03	90	8	0.260 33.22	20	20	40	55	70
For SV, MA, UP, DN, make proper adjustments																				

The polarity for C800 is given as “Polarity (−)”in the table, but as “Reverse Polarity (+)”in actual “CONDITION FILE”. This is because it is mainly intended for electrode forming.

C800 Machining Condition File

CuW—Cu(Electrode Forming)

		Electric Discharge Condition Parameters											Machining Condition		Machining Performance					
	NO.	ON	OFF	MA	IP	SV	PL	V	HP	PP	C	S	Mean Voltage/V	Mean Current/A	Machining Rate g / min mm^3 / min	Surface Roughness μ Rmax	Electrode Wear Ratio E/W*100%	Overcut（μ） α	β	γ
1	C800	001	030	03	000.0	05	−	01	010	10	01	03	90	—	0.001 0.1	2	4	10	15	30
2	C810	001	030	03	000.0	05	−	01	012	10	01	03	90	—	0.006 0.6	2	5	10	15	30
3	C820	001	030	03	000.0	05	−	01	015	10	02	03	90	—	0.010 1.2	3.	6	10	15	30
4	C830	001	030	03	000.0	05	−	01	017	10	03	03	90	—	0.020 2	3	6	10	15	30
5	C840	002	031	03	005.0	05	−	01	012	10	04	03	100	0.5	0.030 3	6	10	15	30	45
6	C850	002	031	03	012.0	05	−	01	012	10	06	03	80	1.5	0.040 5	7	7	20	40	55
7	C860	003	031	03	015.0	05	−	01	011	10	07	03	80	2	0.070 8	8	7	30	45	70
8	C870	003	031	03	023.0	05	−	01	011	10	08	03	80	3	0.140 16	11	7	40	55	80
9	C880	003	031	03	031.0	05	−	01	011	10	09	03	70	4.5	0.260 29	13	7	45	60	90
10	C890	003	031	03	031.0	05	−	02	011	10	09	03	80	8	0.630 70	15	6	50	70	100
For SV, MA, UP, DN, make proper adjustments																				

The polarity for C800 is given as “Polarity (−)”in the table, but as “Reverse Polarity (+)”in actual “CONDITION FILE”. This is because it is mainly intended for electrode forming.

C800 Machining Condition File

CuW—CuW(Proper-Wear)

		Electric Discharge Condition Parameters											Machining Condition		Machining Performance					
	NO.	ON	OFF	MA	IP	SV	PL	V	HP	PP	C	S	Mean Voltage/V	Mean Current/A	Machining Rate g / min mm^3 / min	Surface Roughness μ Rmax	Electrode Wear Ratio E/W*100%	Overcut（μ） α	β	γ
1	C800	001	030	03	000.0	05	−	01	010	10	01	03	70	—	0.001 0．06	3	20	—	—	—
2	C810	001	030	03	000.0	05	−	01	012	10	01	03	60	—	0.002 0．13	4	25	—	—	—
3	C820	001	030	03	000.0	05	−	01	015	10	02	03	70	—	0.003 0．2	4	30	—	—	—
4	C830	001	030	03	000.0	05	−	01	017	10	03	03	70	1	0.004 0．3	5	30	—	—	—
5	C840	002	031	03	005.0	05	−	01	012	10	04	03	70	2	0.010 0．8	6	32	—	—	—
6	C850	002	031	03	012.0	05	−	01	012	10	06	03	80	1.5	0.030 2	7	32	—	—	—
7	C860	003	031	03	015.0	05	−	01	011	10	07	03	80	2	0.040 3	7	34	—	—	—
8	C870	003	031	03	023.0	05	−	01	011	10	08	03	80	3	0.070 5	8	35	—	—	—
9	C880	003	031	03	031.0	05	−	01	011	10	09	03	40	6	0.230 17	10	42	—	—	—
10	C890	003	031	03	031.0	05	−	02	011	10	09	03	40	7	0.250 19	12	40	—	—	—
For SV, MA, UP, DN, make proper adjustments																				

The polarity for C800 is given as “Polarity (−)”in the table, but as “Reverse Polarity (+)”in actual “CONDITION FILE”. This is because it is mainly intended for electrode forming.

C101 Machining Condition File
Cu—St(No-Wear PIKADEN1)

		Electric Discharge Condition Parameters											Machining Condition		Machining Performance					
	NO.	ON	OFF	MA	IP	SV	PL	V	HP	PP	C	S	Mean Voltage/V	Mean Current/A	Machining Rate g / min mm[3] / min	Surface Roughness μRmax	Electrode Wear Ratio E/W*100%	Overcut（μ） α	β	γ
1	C101	011	011	02	001.5	06	+	01	051	01	00	02			0.002 0.25	8-9	0.5	20	50	70
2	C111	012	012	02	002.5	06	+	01	051	01	00	02			0.0099 1.27	13-15	0.15	30	70	90
3	C121	014	014	02	003.5	06	+	01	051	01	00	02			0.024 5.75	16-18	<0.1	35	80	100
4	C131	015	015	02	004.5	06	+	01	051	01	00	02			0.050 6.39	22-25	<0.1	40	90	115
5	C141	016	016	02	005.5	06	+	01	051	01	00	02			0.095 12.1	26-30	<0.1	50	100	130
6	C151	017	017	02	006.5	06	+	01	051	01	00	02			0.120 15.3	30-34	<0.1	60	120	140
7	C161	018	018	02	007.5	06	+	01	051	01	00	02			0.170 21.7	35-40	<0.1	70	130	170
8	C171	019	018	02	010.5	06	+	01	011	01	00	02			0.310 39.6	40-45	<0.1	90	190	220
9	C181	020	020	02	015.5	06	+	01	011	01	00	02			0.580 74.1	45-50	<0.1	120	250	320
10	C191	021	021	02	020.5	06	+	01	011	01	00	02			1.400 179.0	50-55	<0.1	150	290	370
For SV, MA, UP, DN, make proper adjustments																				

C102 Machining Condition File

Cu—St(No-Wear PIKADEN2)

		Electric Discharge Condition Parameters											Machining Condition		Machining Performance					
	NO.	ON	OFF	MA	IP	SV	PL	V	HP	PP	C	S	Mean Voltage/V	Mean Current/A	Machining Rate g / min mm^3 / min	Surface Roughness μRmax	Electrode Wear Ratio E/W*100%	Overcut（μ） α	β	γ
1	C102	011	011	02	001.5	05	+	01	051	11	00	02			0.002 0.26	8-9	1.5	10	30	50
2	C112	012	012	02	002.5	05	+	01	051	11	00	02			0.0085 1.09	13-15	0.4	15	60	80
3	C122	014	014	02	003.5	05	+	01	051	11	00	02			0.020 2.56	16-18	0.15	30	70	90
4	C132	015	015	02	004.5	05	+	01	051	11	00	02			0.052 6.64	22-25	0.1	60	90	110
5	C142	016	016	02	005.5	05	+	01	071	11	00	02			0.110 14.1	26-30	<0.1	70	110	130
6	C152	017	017	02	006.5	05	+	01	071	11	00	02			0.150 19.2	30-34	<0.1	80	120	160
7	C162	018	018	02	007.5	05	+	01	071	11	00	02			0.220 28.1	35-40	<0.1	90	160	200
8	C172	019	019	02	010.5	05	+	01	031	11	00	02			0.360 46.0	40-45	<0.1	120	210	250
9	C182	020	020	02	015.5	05	+	01	031	11	00	02			0.750 95.8	45-50	<0.1	140	270	310
10	C192	021	021	02	020.5	05	+	01	031	11	00	02			1.200 153.0	50-55	<0.1	160	300	360
For SV, MA, UP, DN, make proper adjustments																				

C301 Machining Condition File

CuW—St(Low-Wear Machining PIKADEN3)

		Electric Discharge Condition Parameters											Machining Condition		Machining Performance					
	NO.	ON	OFF	MA	IP	SV	PL	V	HP	PP	C	S	Mean Voltage/V	Mean Current/A	Machining Rate g / min mm^3 / min	Surface Roughness μ Rmax	Electrode Wear Ratio E/W*100%	Overcut (μ) α	β	γ
1	C301	009	037	01	001.5	05	+	00	051	10	00	02			0.0015 0.19	6—7	1.0	—	—	—
2	C311	009	037	01	001.5	05	+	01	051	10	00	02			0.0015 0.65	8—9	3.6	—	—	—
3	C321	009	037	01	002.5	05	+	01	051	10	00	02			0.0015 1.92	11—12	1.8	—	—	—
4																				
5																				
6																				
7																				
8																				
9																				
10																				

For SV, MA, UP, DN, make proper adjustments

C302 Machining Condition File

CuW—St(Low-Wear Machining PIKADEN4)

		Electric Discharge Condition Parameters											Machining Condition		Machining Performance					
	NO.	ON	OFF	MA	IP	SV	PL	V	HP	PP	C	S	Mean Voltage/V	Mean Current/A	Machining Rate g / min mm^3 / min	Surface Roughness μRmax	Electrode Wear Ratio E/W*100%	Overcut（μ）		
																		α	β	γ
1	C312	009	037	01	001.5	03	+	01	040	01	00	02	60	1	0.0036 0.46	8−9	1.0	—	—	—
2	C322	009	038	01	002.5	03	+	01	040	01	00	02	60	2	0.0063 0.81	11−12	0.6	—	—	—
3																				
4																				
5																				
6																				
7																				
8																				
9																				
10																				
For SV, MA, UP, DN, make proper adjustments																				

Cu-St Machining Condition File

		Electric Discharge Condition Parameters											Machining Condition		Machining Performance					
	NO.	ON	OFF	MA	IP	SV	PL	V	HP	PP	C	S	Mean Voltage/V	Mean Current/A	Machining Rate g / min mm^3 / min	Surface Roughness μ Rmax	Electrode Wear Ratio E/W*100%	Overcut (μ)		
																		α	β	γ
1		022	046	01	0310	02	+	01	000	00	00	00	40	40	2.500 321	110	0.91	361	335	279
2		023	047	01	0450	02	+	01	000	00	00	00	40	60	3.700 474	120	0.92	469	428	386
3		024	048	01	0600	02	+	01	000	00	00	00	40	80	5.000 641	140	0.93	582	559	474
4																				
5																				
6																				
7																				
8																				
9																				
10																				
For SV, MA, UP, DN, make proper adjustments																				

Gr-St Machining Condition File
(Electrode Wear Ratio: below 1%)

	NO.	Electric Discharge Condition Parameters: ON	OFF	MA	IP	SV	UP	DN	LN	STEP	PL	V	HP	PP	C	S	L	Machining Condition: Mean Voltage /V	Mean Current /A	Feed (mm)	Machining Performance: Machining Rate g / min	Machining Rate mm^3/min	Surface Roughness μRmax	Electrode Wear Ratio (%)	Overcut (μ) β	Overcut (μ) γ	Fluid Pressure kg/cm^2
1		012	006	00	0050	2	00	00	0	000	+	02	000	00	00	01	0	35	10.5	15	0.270	35	30	0.4	90	70	0.3
2		012	006	00	0070	2	00	00	0	000	+	02	000	00	00	01	0	35	11	15	0.700	90	43	0.7	100	80	0.3
3		013	007	00	0100	2	00	00	0	000	+	02	000	00	00	01	0	35	12	20	1.170	150	57	0.5	110	90	0.3
4		013	013	00	0150	3	00	00	0	000	+	02	000	00	00	01	0	45	25	20	1.400	180	65	0.5	130	110	0.3
5		013	017	00	0200	2	00	00	0	000	+	02	000	00	00	01	0	45	32	30	2.300	290	72	0.7	135	125	0.3
6		013	017	00	0250	2	00	00	0	000	+	02	000	00	00	01	0	45	40	30	3.200	405	78	0.8	145	135	0.3
7		014	017	00	0310	2	00	00	0	000	+	02	000	00	00	01	0	45	43	30	3.900	500	90	0.6	175	160	0.3
8		015	015	00	0630	4	00	00	0	000	+	02	000	00	00	01	0	50	74	50	7.500	964	110	0.6	240	210	0.3
9																											
10																											

For SV, MA, UP, DN, make proper adjustments

Gr-St Machining Condition File

（Electrode Wear Ratio：1%～2%）

		Electric Discharge Condition Parameters																Machining Condition			Machining Performance					
	NO.	ON	OFF	MA	IP	SV	UP	DN	LN	STEP	PL	V	HP	PP	C	S	L	Mean Voltage /V	Mean Current /A	Feed (mm)	Machining Rate g / min mm^3/min	Surface Roughness μRmax	Electrode Wear Ratio (%)	Overcut (μ) β	γ	Fluid Pressure kg/cm^2
1		011	006	00	0050	02	00	00	0	000	+	02	000	00	00	01	0	35	10	15	0.320 41	28	1.3	85	70	0.3
2		011	006	00	0070	02	00	00	0	000	+	02	000	00	00	01	0	35	10.5	15	0.780 100	39	1.5	95	80	0.3
3		011	007	00	0100	02	00	00	0	000	+	02	000	00	00	01	0	35	11.5	20	1.300 170	47	1.5	105	85	0.3
4		011	008	00	0150	03	00	00	0	000	+	02	000	00	00	01	0	45	24	20	1.600 210	55	1.9	115	100	0.3
5		011	017	00	0200	02	00	00	0	000	+	02	000	00	00	01	0	45	28	30	2.300 300	60	1.9	130	110	0.3
6		012	017	00	0250	02	00	00	0	000	+	02	000	00	00	01	0	45	38	30	3.300 420	78	1.5	150	130	0.3
7		012	017	00	0310	02	00	00	0	000	+	02	000	00	00	01	0	45	40	30	4.100 520	75	1.6	170	140	0.3
8		012	012	00	0630	04	00	00	0	000	+	02	000	00	00	01	0	50	69	50	7.000 900	85	1.7	210	165	0.3
9																										
10																										
For SV, MA, UP, DN, make proper adjustments																										