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Short Circuit Coordination of Contactors: Factors Influencing Contact Welding

Vijay Saxena[1], Geetam Richhariya[2]

Abstract - The outcome of short circuit coordination tests with contactors tests with contactors and the characteristics of the short circuit protective of the short circuit protective devices (SCPD) are compared. This leads to the conclusion that certain definite relations exist between the cut-off current, total clearing time and joule-integral of the SCDP on one hand and the contactor characteristics like contact, mass of the contact bridge, contact spring force etc. on the other hand, which may lead to the welding of contacts. The influence of varying design parameters like the mass of the contact bridge and contact spring force of the contactor is demonstrated with simulated short circuit tests. By a proper choice of these parameters, the chances of welding of contacts with the specified SCPD reduce to a minimum.

Keywords: Welding of contacts, contact welding, short circuit coordination, coordination of contactors with SCPD, short circuit protection.

I. INTRODUCTION

One of the main applications of contactors is switching of motors. The contactor is protected by a short circuit is protected device (SCPD) - a circuit breaker or a fuse which also protects the motor including the Connecting wires against short circuits. All these devices must be carefully matched or coordinated with one another for the whole range of application. The project engineer must also be able to predict the level of damage, if any, occurring to the different components in the case of a fault, say short circuit.

Welding of contacts is one of the main problems faced during short circuit coordination tests for contactors with SCPDS. Especially critical are coordination's with circuit breakers with poor current limiting characteristics or with fuses in the intermediate range of prospective short circuit currents. THE II. REASONS OF CONTACT WELDING ARE AS FOLLOWS:

Contact welding in contactors takes places during closing of contacts or during opening and again immediate reclosing of contacts because of the following reasons:

1)Inrush currents exceeding the making capacity of contactors:
2)Unstable control voltage
3)Use of diodes as surge suppressors
4)Transition times too low
5)End of electrical endurance

In the stationary On-state of the contacts, if the let-contacts may soften due to the heat generated at the current construction not may even melt and weld. Due to contact bouncing during switching on (closing) due to the lifting contacts (throw-off) due to the electrodynamics forces if a relatively high current flows through the contacts.

In This paper does not consider the first two factors and deals exclusively with the third point-this being the main reason the welding during a short circuit coordination test. The put-off current (Ic) and joule-integral n(fI2dt) of SCPDS as a function of the prospective short circuit currents (fault level) are usually known from catalogues. These can be represented in a diagram as i2dt=f(Ic). Fig. 1 shows such a diagram for 2 different sizes of fuses and 2 different circuit breakers-current limiting characteristics. The corresponding prospective S.C. currents are also noted on the characteristics. The differences between the protective characteristics of the two types of SCPDS are apparent from this diagram. For contactors, the range where welding of contacts occurred and be determined from various S.C. tests.

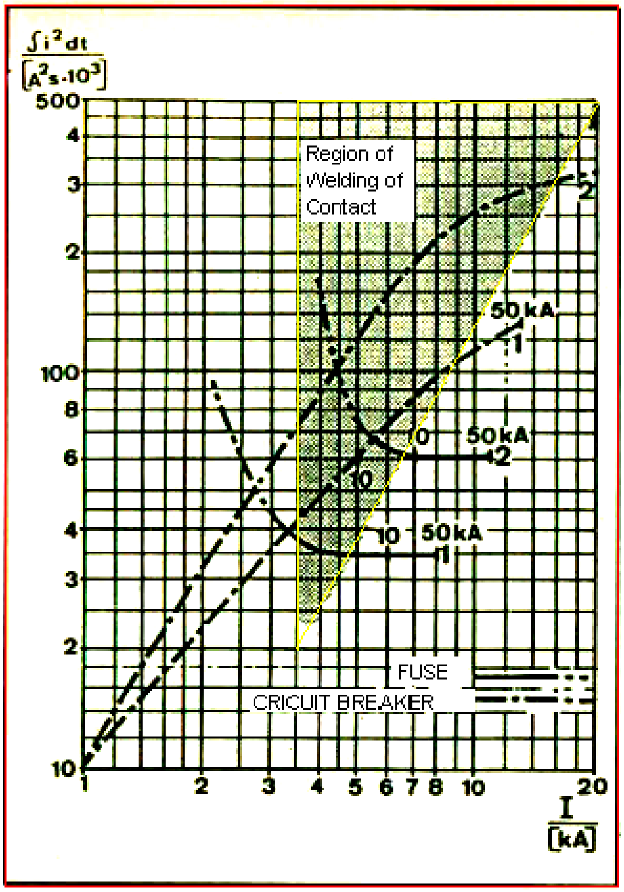

Fig:-1 Characteristics of SCPDs and the region of welding of Contacts.

This is also represented as a shaded area on the same diagram-fig.1.A study of these diagrams leads to the conclusion that there are certain definite relations between the cut-off current, total clearing time and the joule-integral of the SCPD on one hand and the contactor characteristics like contact material, throw-off current, mass of the contact bridge, contact spring force etc. on the other hand, which may lead to the welding of contacts.

Circuit Breaker -1. Current Limiting 2. Not Current Limiting

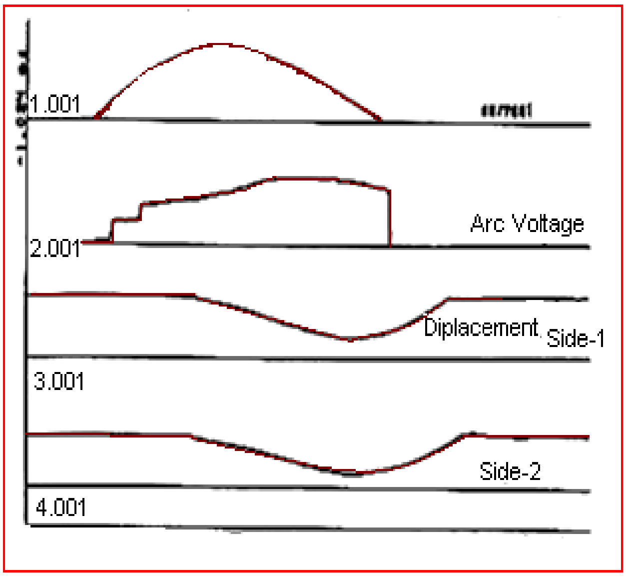

Fig.2 Typical Recording of test Results

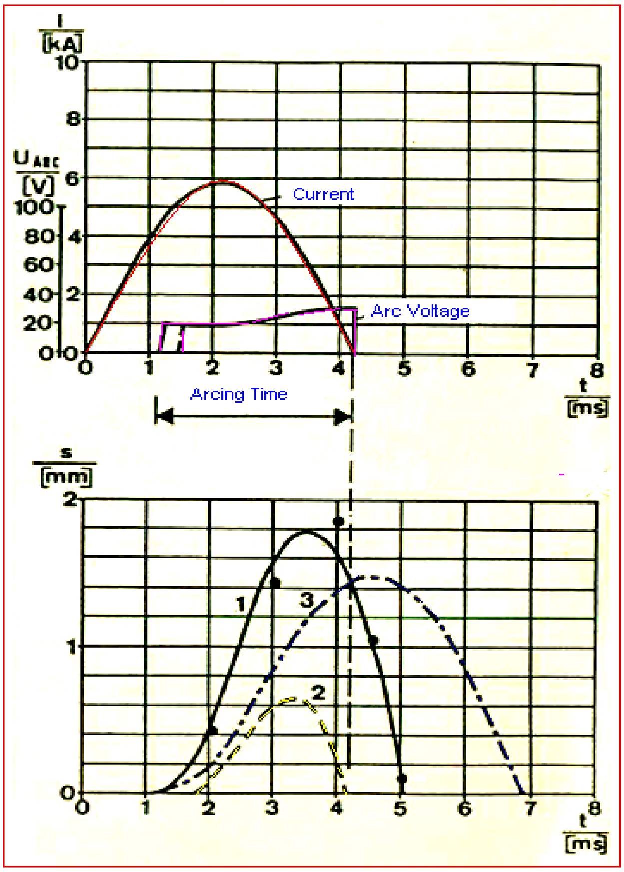

Fig . 3 Influence of Different Parameters on contact

Dynamic(S=displacement)

——— Var.1:Lighter Bridge, Weaker spring

--------- Var.2: Lighter Bridge, Stronger spring

------Var.3 : Heavier Bridge, Weaker spring

•Measured points Var.1

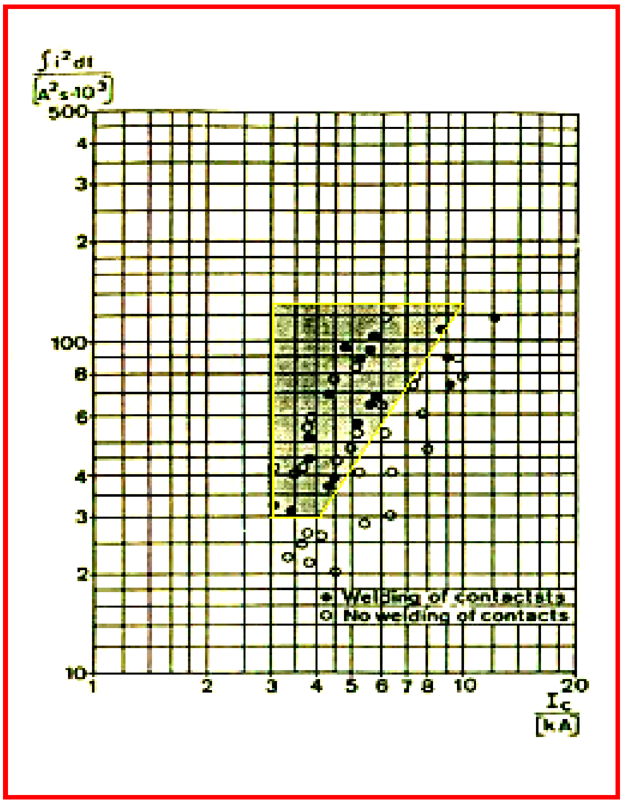

Fig.4 Var. 1: Lighter Bridge Weaker Spring

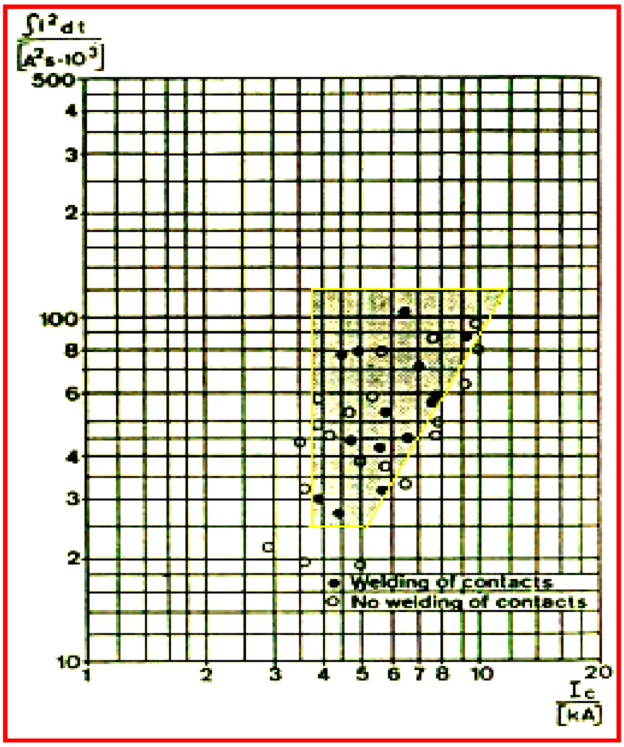

Fig.5 Var. 2: Lighter Bridge, Stronger Spring

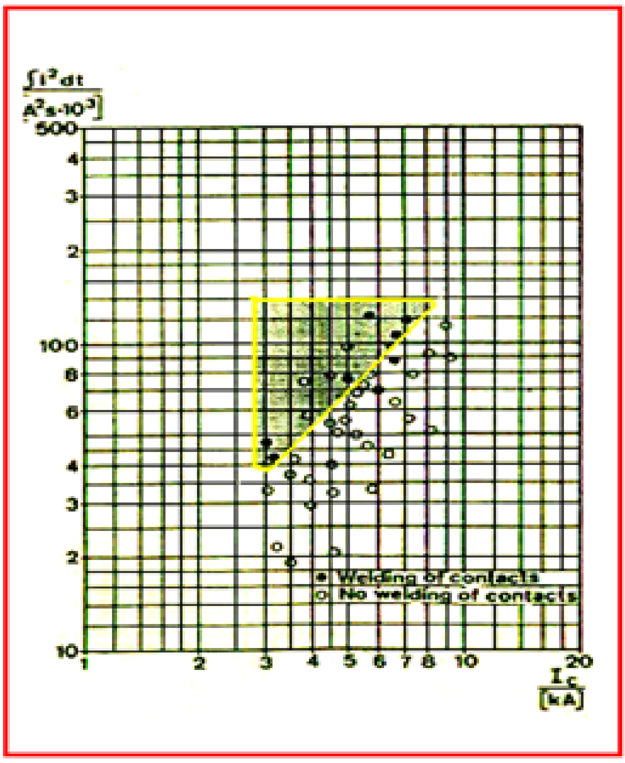

Fig.6: Var. 3: Heavier Bridge Weaker Spring

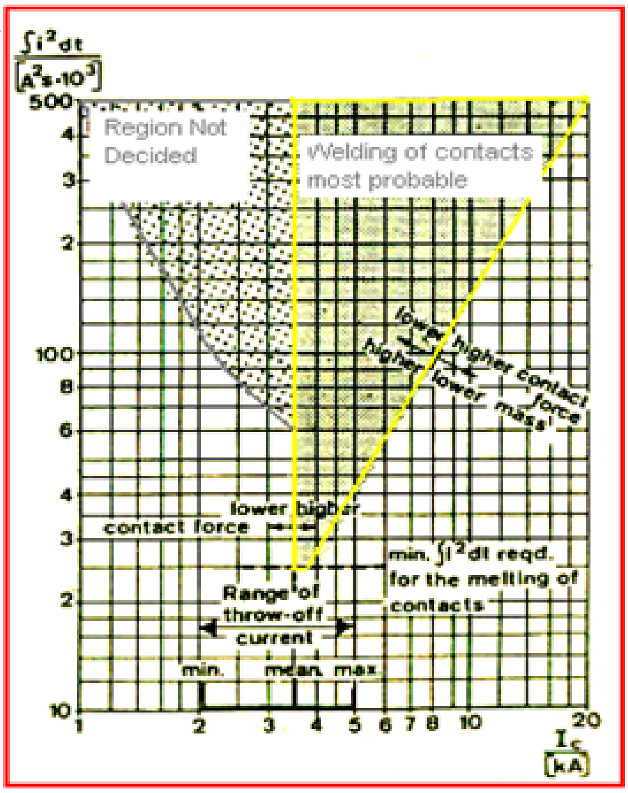

Fig.7 Influence of different parameters on the welding contacts

IV. DESCRIPTION OF THE TEST SET-UP

The let-through characteristics (Ic and I^2 dt) of SCPDS are simulated by a capacitor-battery with proper electronic controls. With variable C, L, R and the charging voltage Uc, a very wide range of current forms can be simulated. The current form is damped sinusoidal, which approaches the let-through current form of a current limiting circuit breaker very closely. Single pole tests were carried out with a contactor rated at 60A (AC-3) and with double break contacts. The contactor was closed prior to the test and the simulated S.C. current initiated by thyristors. The following parameters are registered by a 4-channel transient recorder:

- The current form measured over a shunt
- Total arc-voltage across the double break contact
- The displacement of the contact bridge on both sides with the help of an electro-optical displacement inducer.

A typical recording is shown in fig. 2.

V. TEST PARAMETERS

The dynamic of the contact system can be calculated with sufficient accuracy under given conditions with simplified assumptions. The throw-off force is calculated in two parts and added together:

(a) The component due to the geometrical configuration of the contacts is calculated from the actual geometry.
(b) The component due to cur-rent construction is calculated with the help of empirical formula obtained from various previous measurements.

RATED OPERATIONAL VOLTAGE UE: 415V,50 HZ.

TEST VOLTAGE =415+5%: 436V, 50 HZ.

RATED CONDITIONAL S.C. URRENT IQ: 6 5 KA (rms Symmetrical)
Symmetrical)Type of co-ordination : Type “2”

#4-POLE 415V / 1500 RPM MOTORS

TABLE -1SHORT LRCUIT CO-ORDINATION STARTING: DIRECT-ON-LINE(DOL)

RATING	CURRENT	THERMEL	MAGN.	IAC-3
(kW)	(A)	(A)	(A)	(A)
0.19	0.60	0.40-0.63	6.9	4.8
0.25	0.80	0.63-1.00	11.0	4.8
0.37	1.10	1.00-1.60	18.0	4.8

0.55	1.50	1.00-1.60	18.0	4.8
0.75	1.80	1.60-2.50	28.0	4.8
1.10	2.60	2.50-4.00	44.0	4.8
1.50	3.40	2.50-4.00	44.0	4.8
2.20	4.80	4.00-6.30	69.0	4.8
3.00	6.50	6.30-10.0	110.0	8.2
4.00	8.20	6.30-10.0	110.0	8.2
5.50	11.00	10.0-16.0	176.0	11
7.50	14.00	10.0-16.0	176.0	14
9.00	17.00	16.0-20.0	220.0	21
11.00	21.00	20.0-25.0	220.0	21
15.00	28.00	25.0-40.0	560.0	28
18.50	34.00	25.0-40.0	560.0	37
22.00	40.00	25.0-40.0	560.0	40
30.00	55.00	40.0-63.0	882.0	60
37.00	66.00	63.0-90.0	1260	66
45.00	80.00	80-100	1200	85
55.00	100.00	100-125	1500	105
75.00	135.00	125-160	1900	140
90.00	160.00	125-160	1900	170
110.00	200.00	160-200	2400	230
132.00	230.00	200-250	3000	230
160.00	270.00	250-320	3800	315
200.00	350.00	320-400	4800	425

In fig. 3, typical contact displacements are shown with varying parameters. The measured displacement (in one particular case) is also shown. With the help of such calculations, it was decided to vary the following test parameters:

- The mass of the contact bridge
- The contact spring force

The following combinations were investigated:

- Lighter bridge + weaker spring : var. 1
- Lighter bridge + stronger sping : var. 2
- Heavier bridge + weaker spring : var. 3

The heavier bridge was 2.5 times heavier than the lighter bridge and the stronger spring applied 1.5 times more contact force having, approximately the same spring constant.

VI. TEST RESULTS:

The test results are shown in the figs 4, 5 and 6. Welding of contacts are indicated by dark circles. The regions where welding is most probable are shaded.

VII. CONCLUSIONS:

The test results show that knowing the let-through characteristics of the SCPDS to be used for its protection, the design parameters of a contactor can be so chosen that the chances of welding of contacts reduces to a minimum. Obviously, other design factors like contact bouncing, tem. Rise etc. are also to be considered. Fig. 7 shows a qualitative representation of the influences of the different parameters on the limits of welding of a contractor.

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