PERFORMANCE TESTING AND RELIABLITY OF 2 POLE MAGNETIC LATCHING RELAYS FOR SMART METERS

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Abstract

This is Magnetic latching relay play a very important role in the implementation of the smart meters. These relays have low energy consumption, low cost compared to 2 single pole latching relays and are widely used in smart meters. The performance and quality of the meters are based on magnetic latching relays. This paper discusses the different steps involved in performance testing and Reliability of 2 Pole Magnetic latching relays. Two Pole latching relays replace the 2 single pole latching relays so it increases the reliability and decreases the complexity of the smart meter.
A number of magnetic relay samples have been tested and the outcome says the large current can cause the damage to the relays. In this paper we will discuss different tests which are conducted on latching relays which improve the quality of the smart meters.
The regulatory and IEC standard all metering and latching relay companies has to follow is IEC 62055-31

1 Introduction

Smart meters are used for the measurement of electricity for fast development of smart grids. Latching relays can be controlled by simply applying the trigger pulses. The closed position of the relays can be switched using magnetism. The important features of latching relays are low power consumption and so it is an important component of the smart meter. The performance and quality of the Smart meter depends on latching relays. The problem in quality of the latching relays can cause the fire or the explosion of the smart meters. The Regulators are coming up with many rules and technical specification for the improvement in quality of the product.
The Two pole relays are having many advantages over the single phase relays:

1. Safety and Reliability
2. Consistency
3. Small in Size
4. Convenient Installation

This paper gives details about complete performance testing. The various test performed on the latching relays are:

a) Size & appearance
b) Electrical performance test
c) Environmental adaptability test
d) Product safety test
e) Mechanical life test
f) Electrical life test

2 Why Use Latching Relays for Smart Meters

Sources of Electrical Energy are limited and there is gradual increase in prices in times to come. The best and effective way to save energy is to reduce the cost is Demand Side Management (DSM). DSM contains depletion of peak demand, energy rescue or saving through load switching individually, billing accuracy for consumers and remote connect/ disconnect for the consumers who are refusing to pay their electricity bills.

Demand Side Management (DSM) is practicable because of Latching Relays and Modern electronics. The Latching Relay is the principal component for connect/disconnect of loads and consumers.

3 Relay Production Process

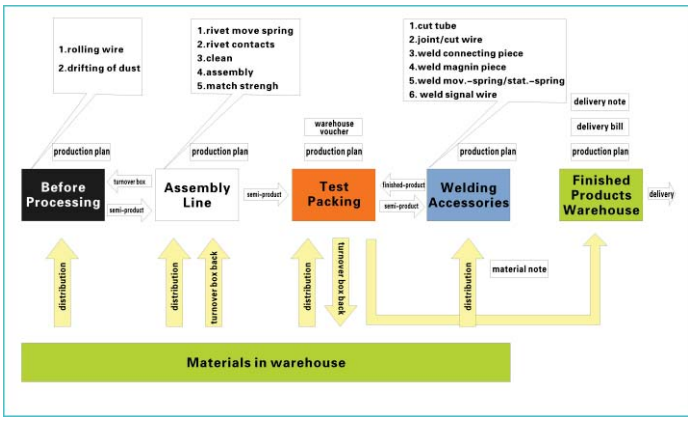

Figure 1: Latching relay production process

4 Implementation and dimension of latching relays

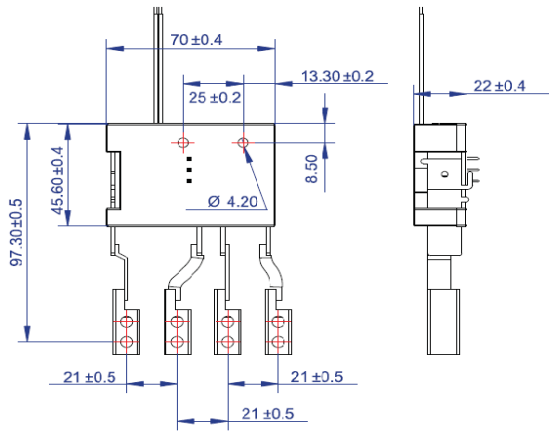

Figure 2: Dimension and connection diagram of 2 pole latching relays

5 Testing Of Magnetic Latching Relays

The magnetic latching relay performance testing is done by using following instruments: Digital multimeter,TOP-962 relay parameter test machine, DF7112 insulation tester, IR thermometer, digital thermometer, constant temperature & humidity box.

5.1 Sample Size and Appearance Inspection

In sample size and appearance inspection test are performed on length, width, height, finish printing, plating and shell flammable. The result of following is displayed on in the figure 1.2.

- Dimension: This test determine the width height and Length of the given relay samples.
- Appearance: Finishing, Printing and plating of the given samples.

The result of all the samples which have been tested found strictly compatible with the specified standard. From the shell flame we can observe that it is qualified on the basis of two kinds of circumstances:

- No flame produced and no heat
- There is fire around the components and it disappered within 30 sec and it did not completely afftect the componenets and have not been completely fired.

Figures and tables should be centred in the column, numbered consecutively throughout the text, and each should have a caption underneath it (see for example Table 1). Care should be taken that the lettering is not too small. All figures and tables should be included in the electronic versions of the full paper.

Form 1		size and appearance: length, width, height, smooth finish, printing, plating.						
Sample no.		1#	2#	3#	4#	5#	6#	Standard
Dimension	Length	70.2	70.2	70.1	70.2	70.2	70.2	70.2±0.4
	Width	45.6	45.5	45.6	45.6	45.7	45.7	45.8±0.4
	Height	22.3	22.3	22.2	22.3	22.2	22.2	22±0.3
Appearance	Finish	√	√	√	√	√	√	Smooth surface, no burr and blister
	Printing	√	√	√	√	√	√	Clear, no short strokes
	Plating	√	√	√	√	√	√	Uniform, no discoloration
Shell flammable		√	√	√	√	√	√	Temp.960℃+10℃ Time:30s+5s
		Test result evaluation: With one of the following two kinds of circumstances, it is judged to be a qualified: 1.Not flame,not hot; 2.There is fire around the components, but gone in 30s, all the components have not been completely fired.						

Table 1: Dimension and connection diagram of 2 pole latching relays

5.2 Basic Electrical performance test

The Basic Electrical test is performed on following parameters: Open and close voltage of the relay, Coil Resistance & Contact resistance, dielectric strength between coil and contact and contact; and betweencontact shown in the fig. 4.

- Coil Resistance: This is the DC resistance of the coil in DC type relays for the different temperature conditions as shown in figure. The operating voltage and contact resistance is slightly varying in all the samples.
- Contact Resistance: It is defined as the total resistance between the terminals, contacts and the spring joined with the contacts and is generally measured in mΩ.
- Operation Voltage: The operation voltage is which closes Contacts when the relay is in Reset state.
- Insulation Resistance: It is the Impedance when the conductor protected with insulating material is exposed to the applied voltage and is measured in MΩ.
- The insulation resistance test is carried out in accordance with standard IEC 60255-5, i.e. 500Vdc ± 10 Tolerance for the minimum time of 5 seconds.

Dielectric Strength: Dielectric strength is the voltage gain, when within the theoretical time the conductors protected with insulating material are exposed the voltage and the leakage current is less than the theoretical current.

Form 2		open and close voltage, coil resistance contact resistance, insulation resistance,dielectric strength between coil&contact,contact & contact.			
Item		Coil resistance	Operation voltage		Contact resistance
Required		18×(1±10%)	≤6.0	≤5.5	≤0.8
Unit		Ω	VDC		mΩ
			open	close	
1#	L-L	17	5.0	4.1	0.35
	N-N				0.36
2#	L-L	17.5	5.1	4.2	0.31
	N-N				0.30
3#	L-L	18.1	4.8	4.3	0.35
	N-N				0.36
4#	L-L	18	4.5	4.5	0.4
	N-N				0.32
5#	L-L	18	4.2	4.3	0.35
	N-N				0.39
6#	L-L	17.5	4.3	4.0	0.42
	N-N				0.41

Table 2: Open & Close voltage, Coil resistance, Insulation Resistance, dielectric strength between coil and contact; contact and contact.

Form 3		insulation resistance,dielectric strength between coil&contact,contact & contact.					
Item		Polarity	Contact state	Insulation resistance		AC voltage clearance	
Test terminal		Coils	Contact team	Between contact and coil	Between contacts	Between contact and coil	Between contacts
Condition		---	---	500VDC	500VDC	>4000 VAC	>2000VAC
Required		Polarity consistency	Close state	>1000 MΩ	>1000 MΩ		
1#	L-L	√	√	√	√	√	√
	N-N						√
2#	L-L	√	√	√	√	√	√
	N-N						√
3#	L-L	√	√	√	√	√	√
	N-N						√
4#	L-L	√	√	√	√	√	√
	N-N						√
5#	L-L	√	√	√	√	√	√
	N-N						√
6#	L-L	√	√	√	√	√	√
	N-N						√

Table 3: Insulation resistances, dielectric strength between coil and contact.

5.3 Environmental adaptability test

Various tests are conducted on relays to prove it can withstand the effects of environment where it is expected to work. These following tests are conducted:

• Temperature Test: This test is carried out to ensure that a product can withstand in extreme temperature condition both in cold and hot during storage, transit and in operating conditions.

High temperature test at 70℃: Dry Heat test is performed at 70℃ in oven for 2 hours and it operates at 60cycles/hr with rated pulse voltage, record state during Test, test finish, record state after recovery in room temperature for 1 hour.

Low temperature test: Cold test is performed at 40℃ in cryostat for 2 hours and it operates 60cycles/h with rated pulse voltage, record state during test, test finish, record state after recovery in room temperature for 1 hour.

• Vibration test

Frequency range: 10Hz∽150Hz; 60Hz

Constant Amplitude: 0.075mm; 60Hz

Constant Acceleration: 10m/s2 (lg) for every sweep frequency cycle of 75min. Finish test, checking the relay structure, contact resistance, insulation resistance.

• Impact test: Half-sine shock pulse: peak acceleration: 150m/s2; impulse cycle: 11ms.Finish test, checking the relay structure, contact Resistance, Insulation resistance.

• Constant humidity test: This test stresses the relay by exposing it to the temperature cycling in conjunction to the high humidity.

It is exposed to constant temperature & humidity box at +40℃ ± 2 ℃ and 85 ± 3% Relative humidity for 2 days.

• Finish test, record state after recovery in room temperature for 2h. The result of this test is shown in fig for different relay samples.

Form 4		Environmental adaptability test:Low & high temperature test,Vibration test,Impact test,Constant humidity test										
Item		Test at +70℃			Test at -40℃			Vibration test		Impact test		Constant humidity test	
Parameter		Operation voltage		Contact resistance	Operation voltage		Contact resistance	Contact resistance	Insulation test	Contact resistance	Insulation resistance	Contact resistance	Insulation resistance
		Close	Open		Close	Open			500VDC		500VDC		500VDC
Required		≤6.0	≤5.5	≤0.8	≤6.0	≤5.5	≤0.8	≤0.8	>100	≤0.8	>100	≤0.8	>100
Unit		VDC		mΩ	VDC		mΩ	mΩ	MΩ	mΩ	MΩ	mΩ	MΩ
1#	Before test	5.4	4.2	0.38	5.0	3.9	0.35	0.45	√	0.40	√	0.46	√
				0.40			0.40						
	After test	5.2	4.1	0.38	5.2	4.2	0.40	0.48		0.42		0.48	
				0.42			0.45						
2#	Before test	5.3	4.4	0.35	4.9	3.8	0.38	0.42	√	0.39	√	0.44	√
				0.32			0.35						
	After test	5.1	4.4	0.36	5.2	4.5	0.39	0.43		0.402		0.42	
				0.39			0.40						

Table 4: Environmental adaptability test and constant humidity test

5.4 Product Safety Test

2.2.1. The product load loop between the end leads to electric clearance and creep age distance should meet:

- *Electrical clearance*≥4mm
- *Creep age distance* ≥5mm
- *Contact temperature raise test*: Rated 250VAC*100A
- *Relay contact terminal temperature raise should not exceed 55K at 40 ℃ environmental temperature.*
- *Contact group and coil group leads impact test:*
- Temperature (23 + 1) ℃, (50 + 2) % RH
- *Atmospheric pressure*: (86 ~ 106) kPa,
- *Rated impulse voltage:* 6000V AC, during test disruptive discharge did not appear (spark, flashover or breakdown) and records.

2.2.2 Load test:

- Relay withstand 1.5 times rated current at the operating frequency of (10±1) times /minute and circulates 100 times contact without the stick and welding dead.
- Relay withstand 30 times short-circuit current, time is 10ms, operate three times, interval at least 1 min/time. Contact without stick, welding dead.

Form 5		Electrical clearance	Creepage distance	Temperature raise test		Contact group and coil group leads impact test			Mechanical performance test	
Item				Movable contact spring	Static contact spring	Close voltage	Open voltage	Contact resistance	Impact test	Vibration test
Condition				24℃，Imax=100A		6000Vac			Acceleration: 150m/s²	half-sine shock pulse
Required		≥4mm	≥5mm	≤55		≤6.0	≤5.5	≤0.8	No change in contact state	No change in contact state
Unit				℃		VDC	VDC	mΩ	---	---
1#		--	--	--		--	--	--	√	√
2#		--	--	--		--	--	--	√	√
3#	L-L	62	7	28	45	5.1	4.2	0.35	--	--
	N-N	62	7	30	42			0.36		
4#	L-L	62	7	29	44	4.8	4.3	0.4	--	--
	N-N	62	7	32	41			0.32		

Table 5: Product Safety test

Form 6	Short-time over current test	
Condition	1.5 times rated current	30 times current
Required	operate frequency (10±1) times /minute, circulate 100 times, contactor no stick, welding dead	time is 10ms, operate three times, interval at least 1 min/time.contactor no stick, welding dead
3#	√	√
4#	√	√

Table 6: Short time over current test

5.5 Mechanical Life

The number of operations can be expected by a latching relay to deliver while maintaining the mechanical integrity of the device. The testing procedure for mechanical life of the relays generally tested with no load or the voltage applied to the power terminals.

The figure shows the table of relay operations without load or non-loaded condition.
Contact add 10~50mV, operate 3cycles/record after 10h.

Form 7		Mechanical life test					
Item		Mechanical life test					
Condition		Non-loaded					
Required		Before(contact add 10~50mV,operate 3cycles/s)			After(10h 108000cycles)		
		Close ≤6.0VDC	Open ≤5.5VDC	Contact resistance ≤0.8mΩ	Close ≤6.0VDC	Open ≤5.5VDC	Contact resistance ≤0.8mΩ
1#	L-L	5.5	4.2	0.40	5.4	4.4	0.45
	N-N			0.45			0.46
2#	L-L	5.2	4.5	0.39	5.5	4.56	0.42
	N-N			0.40			0.45

Table 7 :Mechanical Life of the latching relays

5.6 Electrical Life

The minimum number of times relay can be operated with a specific load switched by contacts in nominal conditions.

- At 250VAC, 100A, open and close cycles for the relay (open/1S, close/2S) are 5000 cycles.
- At 0.5pf, inductive load 250VAC, 100A, Open and close (open/1S, close/2S) is 5000 cycles. Contact without stick, welding dead.
- The dielectric Pressure resistance should not be less than 75% of the initial value 2000V.
- The insulation resistance ≥100MΩ, contact pressure drop should not exceed 1.5 times of the specified value.

Form 8		Electrical life test							
Item		Electrical life test							
		Resistive load test			Inductive load test				
Condition		250V 100A			250V 100A 0.5PF				
Required		5000 cycles (Open 1S/ Close 2S),contact without stick, welding dead			5000 cycles(Open 1S/ Close 2S),contact without stick, welding dead. Contact resistance≤1.2mΩ				
		Close ≤6.0VDC	Open ≤5.5VDC	Contact resistance ≤0.8mΩ	Contact resistance ≤1.2mΩ 2500cycles	Contact resistance ≤1.2mΩ 5000cycles	Contact resistance ≤1.2mΩ 10000cycles	Dielectric pressure >2*0.75(KV)	Insulation resistance >100MΩ/500VDC
5#	L-L	4.8	4.7	0.6	1.0	1.1	1.1	√	√
	N-N			0.7	0.8	0.9	1.0		
6#	L-L	4.9	4.8	0.5	1.1	1.0	0.9	√	√
	N-N			0.4	0.7	0.7	0.8		

Table 8: Electrical Life of Latching relays

6 Relay Connection Diagram

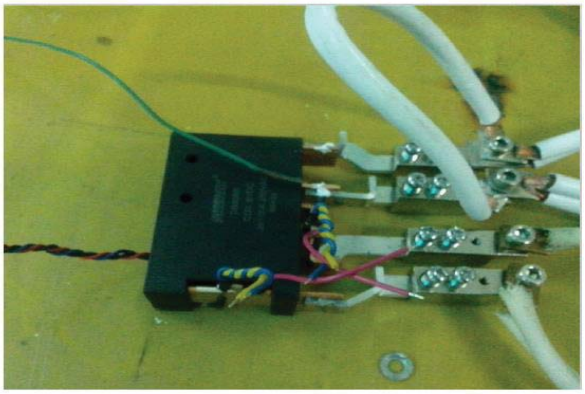

Figure 3: Relay Connection Diagram

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7 Conclusion

Two Pole relays are more reliable then single pole relays. The various test performed on the different relay samples satisfy the reliability and Performance of the 2 Pole relays for smart Meters. The two pole relays are more reliable, small in size, convenient installation; Price is less compared to 2 single pole relays.

References

[1]Chen Sheng, Zhang Phenge, Xue Yang, Xia Fuquan, Chen Siyu, Xu Jiajia,, " Analysis and Application on performance testing system for magnetic Latching Relay Used in Smart Meter" *Applied Mechanics and Materials, vol,. 568-570(2014) pp. 448-451.*

[2] Test report Ramway Technology Co. Ltd. No. RY908100001*, 100 Amps 2 Pole Latching Relays.*

[3] Network Automation and Guide, *Relay testing and commissioning.*

[4] Relay Technical Information ds x61en relay technical information 090712D.

[5] Editor- Metering International "The latching relay for consumer and load management*" November 14, 2008*

[6] IEC62055-31 Electricity metering - Payment systems - *Part 31: Particular requirements - Static payment meters for active energy (classes 1 and 2)*

Authors' Profile

Shridhar Pandey is presently working as a Country Manager with Ramway Technology Co. Ltd., China and Director –Sales and marketing with Komalay Techtronics Pvt. Ltd. India. He has been working on Lithium battery Technology and Latching Relays for Medical Electronics, AMI/AMR, Smart Meters and Energy Meters. He has written many articles on lithium batteries, Latching relays and smart meters for many Electronics and Electrical magazines.

Anish Garg is an Electrical Engineer with specialization in Finance. He has over 19 years of experience in Power Sector, ranging from Power Plant Operation and Maintenance, Implementation of DSM measures, Technical Analysis and Monitoring of Capital Expenditure Schemes of Distribution Utilities and Generation Utilities & Regulatory Sector. He has wide exposure, with hands-on experience in the field of Thermal Power Generation, as well as in Regulatory Commissions. His current areas of interest are Smart Grid implementation, Demand Response and Loss Reduction Strategies in Distribution Utilities.