TITLE

Long Term Maintenance and Care for Reyrolle LM23T/LMT2

E. C. Wright 27/09/04

This document is to be used in conjunction with Installation, Operation and Maintenance Schedule IOMS 577 & 920. Its aim is to provide guidance for owners of equipment which has been in service more than 20 years.

Contents –

Introduction

During normal every day operation, switchgear works well within its design envelope and therefore, even after many years of service, appears superficially to be OK.

Fault clearance however may require the equipment to work at near maximum performance and substandard equipment will be susceptible to significant damage.

To maintain rating capability key components/functions must be in good operational condition:

The above does not indicate that the product has a limited lifespan, if fact the LMT range has proven to be very reliable when well looked after.

We can actually take advantage of the sub-station history of older equipment to design bespoke maintenance, which will not only extend the working life but will reduce the chance of catastrophic damage and can even reduce maintenance costs.

The owner of older equipment (20 years and beyond) should have the information which will allow him to design a maintenance plan to suit his needs. This document will help with that process.

Key Questions

1. How often is the equipment switched?
2. Is this switching duty at full rated current or well below rated current?
3. How often does the system see a fault?
4. What environmental conditions exist within the sub-station? – Is the switchgear dirty or damp or both? (we are concerned here mainly with the primary insulation)
5. Do we know the condition of the primary functional systems of the switchgear –
    a. Primary Insulation.
    b. Contacts, Turbulators and Oil.
    c. The dynamic operating characteristics of mechanism and contacts.

Points 1 to 4 should be available from historical records and we will look later how we will use this information.

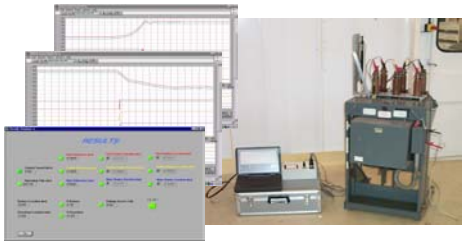
Point 5 is actually our recommended starting point. We feel it is logical to make a condition assessment of the equipment, and instigate any repairs prior to introducing a new maintenance regime. Using the condition assessment approach at suitable intervals will also help ensure full rating capability is maintained.

Condition Assessment

Recommended site testing For condition assessment of Reyrolle LMT.

Speed Curving - In house electronic system

Using original test parameters.



Non-intrusive Discharge

Non-intrusive Discharge Monitoring.

Discharge monitoring is recommended to identify any possible deterioration of filled joints such as the shrouds in the Busbar and Transformer Chambers, surface discharges on primary insulation and similar possible sources.

The system used is non-intrusive. Magnetic probes are attached to the outer skin of the switchgear and are designed to pickup magnetic wave pulses, a phenomenon of electrical discharge. Each probe will pick up a source of discharge but the monitor can determine by time of flight which probe is closest to the source. (see diagrams below) The monitor sweeps the probes approximately every 5 minutes over a period (usually one week) and therefore can determine if the problem is constant, the level and therefore the severity. Recommendations will be given.

Owners of the switchgear can be shown how to transfer monitoring equipment from one board the next and e-mail information to ourselves for analysis.

Partial Discharge Monitoring

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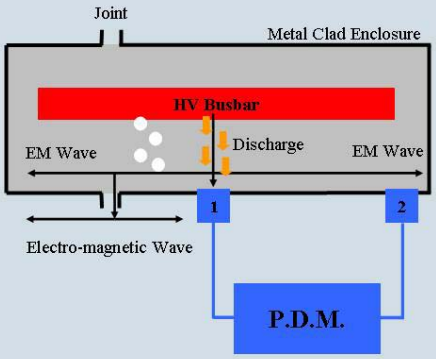
- Charge transferred from HV busbar to earthed enclosure.
- EM waves emanate away from the discharge site.
- EM waves escape through joint in the enclosure and sweep across the surface of the switchgear.
- EM wave detected by the P.D.M.



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Partial Discharge Monitoring

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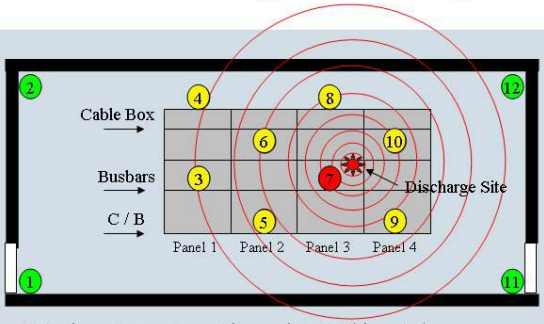

KEY:
Aerial
Probe
First to detect discharge

Typical monitoring set-up within a substation (plan view)

- All of the probes detect the discharge from every discharge site on the board.
- The monitor allocates the discharge to the probe at which the discharge arrives first.
- Aerials detect background noise first. Background noise is allocated to aerials.
- The monitor can detect multiple discharge sites within the switchboard.

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Our report gives graphical information, explanation and recommendation for repair.

Part of the graphical information from a recent report is shown below.

Partial Discharge Monitoring

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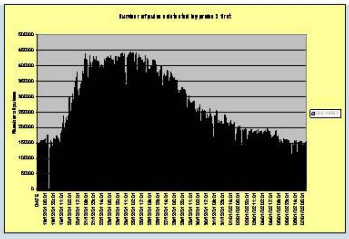


This is a graph from one of our recent surveys.

The probe is situated on a cable box.

This discharge was active constantly at a dangerously high level.

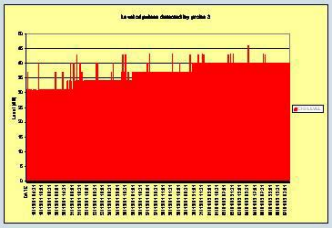
As we can see below, the discharge was getting worse as time went on.

The primary insulation involved here would certainly have failed in the near future if left unattended.

An unplanned outage would have cost this particular customer around £300,000 a day.

This problem would have gone unnoticed if not for the customer requesting a PDM survey.

The cable box was successfully repaired in the shortest time possible. Subsequent PDM surveys have gave 'discharge free' results.



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Dynamic Contact and Mechanism Characteristics

When a circuit breaker design passes its short circuit and mechanical operations type tests, certain dynamic characteristics are recorded and used as a profile in all subsequent routine production tests. In other words every production circuit breaker should have the same rating capability. A typical speed curve is shown below.

Speed Curve

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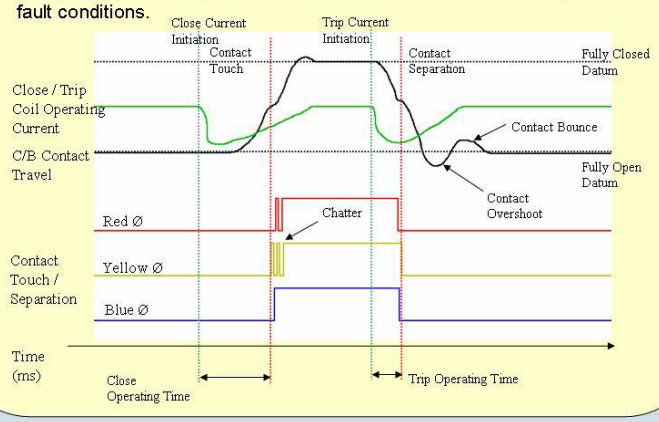
Speed curve analysis allows us to look at the operating characteristics of a circuit breaker in order to determine that it will operate correctly under fault conditions.



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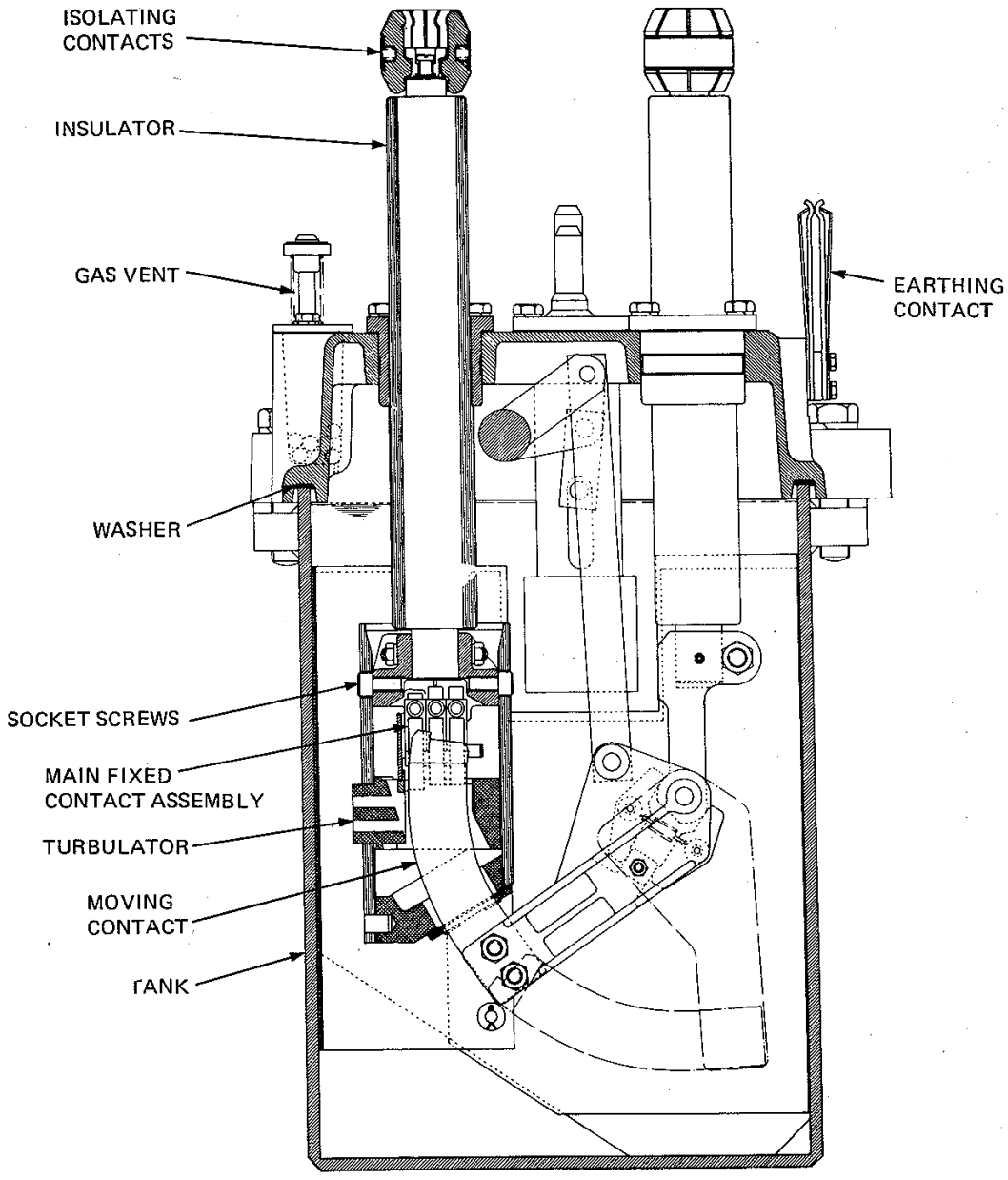
The above test combined with visual inspection of Contacts and Turbulators plus resistance and Oil tests will confirm rating capability.

Oil analysis should measure –

- Breakdown Strength
- Moisture Content
- Acidity

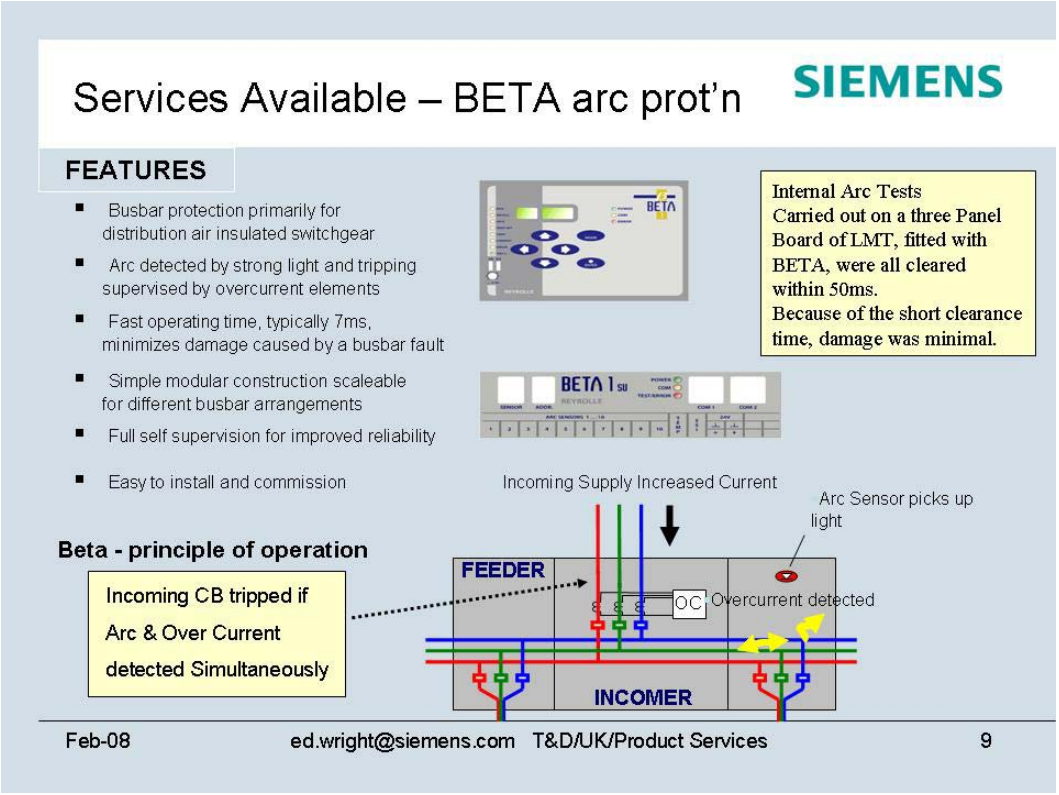


BETA ARC FAULT PROTECTION

In the early 1990's the requirement for Internal Arc Protection on all new Primary Switchgear designs became part of IEC and UK EATS specifications.
The driver for introducing this was of course safety for the operator.
Adding design features to cope with the specification is relatively straight forward when starting a new product design. However retrofitting the capability on existing designs is generally not viable.
The advent of the BETA protection device gives us a viable method of achieving the IEC Arc Fault criteria as a retrofit solution on old air insulated chambers.
As a bonus, BETA not only gives enhanced operator safety, but it dramatically reduces the possibility of collateral damage – Faults will be contained in chamber of origin.
BETA protection can be used to protect the following LMT chambers –

- Circuit Breaker
- Busbar
- Current Transformer
- Air insulated cable boxes. (cable boxes may be compound filled)

The principle of BETA operation is shown below.



Recommended Care Program – Appendix 1

As suggested earlier an alternative program of care to that shown in IOMS577 & 920 should be introduced when the equipment has been in service longer than 20 years.

Spares for normal maintenance needs – Appendix 2

These spares are recommended for the normal wear and aging of the equipment.

Site Issues – Appendix 3

LM23T buffer washer

Retrofit Option – Appendix 4

A Vacuum Interruption Circuit Breaker is available as a Retrofit option for the replacement of oil. This also gives the possibility of up-rating to a maximum of 31.5kA

Factory based Overhaul

When site based maintenance procedures cannot achieve consistent and correct circuit breaker operation. Our factory based overhaul service is designed to bring a circuit breaker back to full rating capability with the minimum work. This is achieved by a process of an initial test and inspection to establish work to be done and an agreement with the customer to proceed.

Traveler circuit breakers can be made available to reduce outage times.

Factory based Rebuild-Refurbishment

This process described below is recommended for circuit breakers older than 25 years. The process is a complete rebuild with replacement of key components and wiring which achieves an almost “As New” result. The end result not only re-establishes rating but dramatically extends the working life of the equipment.

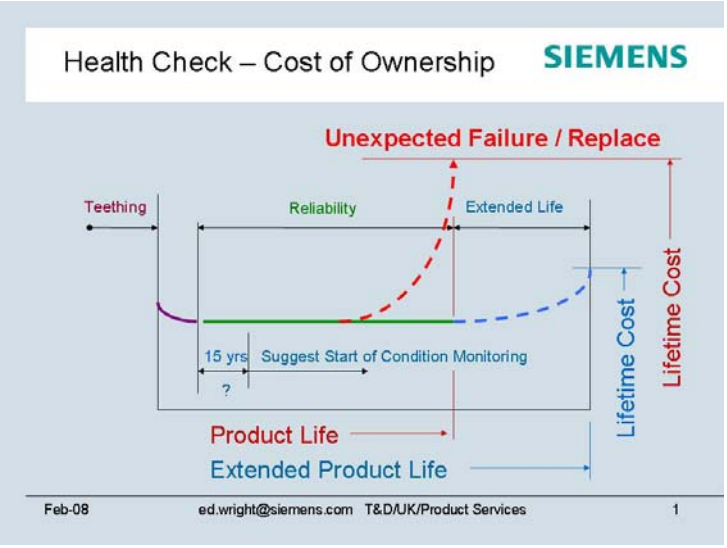
REFURBISHMENT OF LMT SWITCHGEAR

SCOPE OF WORK.

- **Pre-work CB Inspection & Test**
- **Oil Testing,**
- **Internal Inspection,**
- **Full Strip Down To Carcass,**
- **100% Component Inspection,**
- **Replacement of All springs,**
- **Rebuild & Rewire,**
- **Re-Test.**
- **Re-Install**

Recommendation to achieve Life Extension and Low Cost of Ownership.

The process recommended in Appendix 1, a combination of Refurbishment, Condition Assessment and Bespoke Maintenance will extend the working life of the equipment. The logic of this is shown diagrammatically below. The process of targeted or bespoke maintenance also has the potential to reduce maintenance cost.



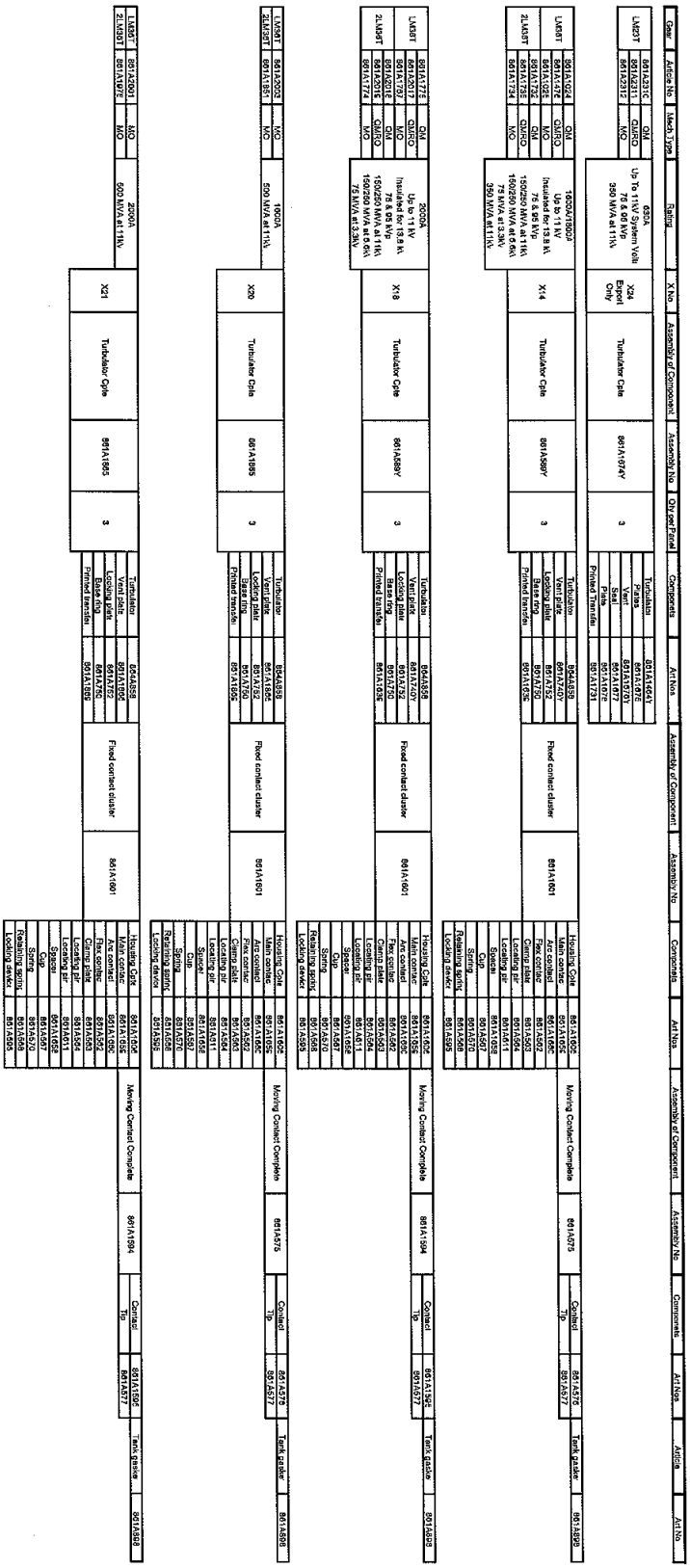
New Cable Box Designs for Polymeric Cables

A number of Air insulated cable boxes are available for both LM23T & LMT2

APPENDIX 1 – Recommended Maintenance Regime for LM23T & LMT2 in service over 20 years.

Interval	Circuit Breaker	Enclosure
25 years	Rebuild Refurbishment	Discharge Monitoring
8 year	Discharge Monitoring Speed Curve Internal Tank Inspection Oil Test Clean and Lubricate	Discharge Monitoring Clean and Lubricate Touch-up paint if necessary
4 year – Only required for poor environments (8 year report may suggest additional tests)	Clean and Lubricate (Discharge Monitoring)	Clean and Lubricate Touch-up paint if necessary (Discharge Monitoring)
Every 2000 operations at low system current.	Clean, lubricate and inspect mechanism.	
Every 2000 operations at high system current.	Clean, lubricate and inspect mechanism. Internal Tank Inspection Oil Test.	
After Fault	Internal Tank Inspection	
Yearly if CB not operated	Electrical Close & Trip several times.	

Gear	Article No	Mech Type	Rating	X No	Assembly of Component	Assembly No	Qty per Panel	Componets	Art Nos	Assembly of Component	Assembly No	Componets	Art Nos	Assembly of Component	Assembly No	Componets	Art Nos	Article	Art No
LM23T	861A215Y	JO	400A	X6	Turbulator Cpte	861A392Y	3	Turbulator	861A311	Fixed Contact Cluster	861A81X	Retaining cup	861A80	Moving Contact Complete	861A15Y	Contact	861A13Y	Tank gaske	861A105
	861A438Y	QM	Up to 11 Kv System Volt					Key piece	861A66			Main contac	861A76			Tip	861A14		
	861A490X	QMRO	Insulated for 13.8 k\					Locking piece	861A839			Arc contact	861A1692						
	861A489	MO	75 & 95 kVp					Moulded nylon ver	861A390X			Spring	861A72						
2LM23T	861A1703	QM	150/250 MVA at 11k\					Liner	861A2273			Distance piece	861A70						
	861A1792Y	QMRO	150 MVA at 6.6 kV									Contact block	861A198C						
	861A1706	MO	75 MVA at 3.3 kV									Flex connecto	861A316						
												Screw	2151-59544E						
LM23T	861A1855Y	JO	630A	X22	Turbulator Cpte	861A392Y	3	Turbulator	861A311	Fixed Contact Cluster	861A81X	Retaining cup	861A80	Moving Contact Complete	861A15Y	Contact	861A13Y	Tank gaske	861A105
	861A1856	QM	Up to 11 kV System Volt					Key piece	861A66			Main contac	861A76			Tip	861A14		
	861A1858Y	QMRO	Insulated for 13.8 k\					Locking piece	861A839			Arc contact	861A1692						
	861A1857	MO	75 & 95 kVp					Moulded nylon ver	861A390X			Spring	861A72						
			150/250 MVA at 11k\					Liner	861A2273			Distance piece	861A70						
			150 MVA at 6.6 kV									Contact block	861A198C						
			75 MVA at 3.3 kV									Flex connecto	861A316						
												Screw	2151-59544E						
LM23T	861A462	JO	800A/1200A	X2	Turbulator Cpte	861A375Y	3	Turbulator	861A348	Fixed Contact Cluster	861A81X	Retaining cup	861A80	Moving Contact Complete	861A367Y	Contact	861A347Y	Tank gaske	861A105
	861A460	QM	Up to 11 kV					Key piece	861A66			Main contac	861A76			Tip	861A14		
	861A492X	QMRO	Insulated for 13.8 k\					Moulded nylon ver	861A390X			Arc contact	861A1692						
	861A461	MO	75 & 95 kVp					Locking piece	861A389			Spring	861A72						
2LM23T	861A1704	QM	150/250 MVA at 11k\					Liner	861A2273			Distance piece	861A70						
	861A1793Y	QMRO	150 MVA at 6.6 kV									Contact block	861A198C						
	861A1714	MO	75 MVA at 3.3 kV									Flex connecto	861A316						
												Screw	2151-59544E						
LM23T	861A1053	JO	400A	X9	Turbulator Cpte	861A878Y	3	Turbulator	861A879	Fixed Contact Cluster	861A81X	Retaining cup	861A80	Moving Contact Complete	861A15Y	Contact	861A13Y	Tank gaske	861A105
	861A1052	QM	13.8 kV System Volt					Key piece	861A66			Main contac	861A76			Tip	861A14		
	861A1063X	QMRO	75 & 95 kVp					Locking Piece	861A389			Arc contact	861A1692						
	861A1057	QM	250/350 MVA at 13.8 k\					Moulded ven	861A390X			Spring	861A72						
2LM23T	861A1725	QM						Liner	861A2273			Distance piece	861A70						
	861A1797Y	QMRO						Seal	861A877			Contact block	861A198C						
	861A1727	MO						Retaining plate	861A876			Flex connecto	861A316						
								Washer	861A2177			Screw	2151-59544E						
LM23T	861A1054	JO	800A/1200A	X12	Turbulator Cpte	861A881Y	3	Turbulator	861A880	Fixed Contact Cluster	861A81X	Retaining cup	861A80	Moving Contact Complete	861A367Y	Contact	861A347Y	Tank gaske	861A105
	861A1055	QM	13.8 kV System Volt					Key piece	861A66			Main contac	861A76			Tip	861A14		
	861A1569X	QMRO	75 & 95 kVp					Locking Piece	861A389			Arc contact	861A1692						
	861A1056	MO	250/350 MVA at 13.8 k\					Moulded ven	861A390X			Spring	861A72						
2LM23T	861A1728	QM						Liner	861A2273			Distance piece	861A70						
	861A1798Y	QMRO						Seal	861A877			Contact block	861A198C						
	861A1729	MO						Retaining plate	861A876			Flex connecto	861A316						
												Screw	2151-59544E						
LM23T	861A680	QM	400A/1000A	X8	Turbulator Cpte	861A589Y	3	Turbulator	864A858	Fixed contact cluster	861A1601	Housing Cpte	861A1606	Moving Contact Complete	861A575	Contact	861A576	Tank gaske	861A652
	861A883X	QMRO	Up to 11 kV					Vent plate	861A740Y			Main contac	861A1659			Tip	861A577		
	861A658	MO	Insulated for 13.8 k\					Locking plate	861A752			Arc contact	861A1660						
2LM23T	861A1722	QM	75 & 95 kVp					Base ring	861A750			Flex contac	861A562						
	861A1796Y	QMRO	250 MVA at 6.6 Kv					Printed transfer	861A1639			Clamp plate	861A563						
	861A1723	MO	350 MVA at 11kV									Locating pin	861A564						
												Locating pin	861A611						
												Spacer	861A1658						
												Cup	861A567						
												Spring	861A570						
												Retaining spring	861A568						
												Locking device	861A595						
LM23T	861A1711	QM	1200A	X15	Turbulator Cpte	861A589Y	3	Turbulator	864A858	Fixed contact cluster	861A1601	Housing Cpte	861A1606	Moving Contact Complete	861A1594	Contact	861A1595	Tank gaske	861A652
	861A1712Y	QMRO	Up to 11 kV					Vent plate	861A740Y			Main contac	861A1659			Tip	861A577		
	861A1710	MO	Insulated for 13.8 k\					Locking plate	861A752			Arc contact	861A1660						
2LM23T	861A2011	QM	75 & 95 kVp					Base ring	861A750			Flex contac	861A562						
	861A2009	QMRO	350 MVA at 11kV					Printed transfer	861A1639			Clamp plate	861A563						
	861A2010	MO										Locating pin	861A564						
												Locating pin	861A611						
												Spacer	861A1658						
												Cup	861A567						
												Spring	861A570						
												Retaining spring	861A568						
												Locking device	861A595						
LM23T	861A1690	QM	400A	X10 Export Only	Turbulator Cpte	861A1674Y	3	Turbulator	861A1464Y	Fixed Contact Cluster	861A81X	Retaining cup	861A80	Moving Contact Complete	861A15Y	Contact	861A13Y	Tank gaske	861A652
	861A1698Y	QMRO	Up To 11kV System Volt					Plates	861A1675			Main contac	861A76			Tip	861A14		
	861A1756	MO	75 & 95 kVp					Vent	861A1676Y			Arc contact	861A1692						
			350 MVA at 11kV					Seal	861A1677			Spring	861A72						
								Plate	861A1678			Distance piece	861A70						
								Printed Transfer	861A1731			Contact block	861A198C						
												Flex connecto	861A316						
												Screw	2151-59544E						



Order	Article No	Mtech Type	Rating	X No	Assembly of Component	Assembly No	Qty per Panel	Components	Art Nos	Assembly of Component	Assembly No	Components	Art Nos	Article	Art No
LM72	971A102	QM	630A System Volts Insulated For 13.8 kV 25kA at 12kV 2 secs 20kA at 12kV 3 secs	X31	Turbulator Cpte	971A178Y	3	Turbulator pin	971A172Y	Fixed contact cluster	971A148	Contact housing	971A148	Moving Contact Complet	971A287	Tanks stable	971A253
	971A310Y	QNRO						Vent locking plate	971A168			Spring retainer	971A141				
	971A320	M/O						Vent	971A171			Arcing contact	971A133				
								Thrust washer	971A175			Contact	971A139Y				
								Screw	3229A6			Retaining clip	971A142				
												Fixed contact	971A135Y				
												Spring	3240A62				
LM72	971A282	QM	1250A System Volts Insulated For 13.8 kV 25kA at 12kV 3 secs	X30	Turbulator Cpte	971A244Y	3	Turbulator pin	971A243Y	Fixed contact cluster	971A237	Contact housing	971A236	Moving Contact Complet	971A284	Tanks stable	971A253
	971A321	QNRO	Up to 12kV					Vent locking plate	971A240			Spring retainer	971A141				
	971A322	M/O						Vent	971A241			Arcing contact	971A213				
								Thrust washer	971A378			Contact	971A214				
								Screw	3229A6			Retaining plate	971A234X				
												Fixed contact	971A231				
												Spring	3240A62				
LM72	971A493	M/O	1250A System Volts Up to 12kV Insulated For 13.8 kV 12.5kA at 12kV 3 secs	X33	Turbulator Cpte	971A244Y	3	Turbulator pin	971A243Y	Fixed contact cluster	971A237	Contact housing	971A236	Moving Contact Complet	971A284	Tanks stable	971A253
								Vent locking plate	971A240			Spring retainer	971A141				
								Vent	971A241			Arcing contact	971A213				
								Thrust washer	971A378			Contact	971A214				
								Screw	3229A6			Retaining plate	971A234X				
												Fixed contact	971A231				
												Spring	3240A62				
LM72	971A411	QM	2500A System Volts Up to 12kV Insulated For 13.8 kV 25kA at 12kV 3 secs	X32	Turbulator Cpte	971A244Y	3	Turbulator pin	971A243Y	Fixed contact cluster	971A237	Contact housing	971A236	Moving Contact Complet	971A284	Tanks stable	971A253
	971A412	QNRO						Vent locking plate	971A240			Spring retainer	971A141				
		M/O						Vent	971A241			Arcing contact	971A213				
								Thrust washer	971A378			Contact	971A214				
								Screw	3229A6			Retaining plate	971A234X				
												Fixed contact	971A231				
												Spring	3240A62				
LM72	971A494	QM	650A System Volts Up to 12kV Insulated For 13.8 kV 25kA at 12kV 2 secs 20kA at 12kV 3 secs Pressure less 42kV for 1 min	X31	Turbulator Cpte	971A175Y	3	Turbulator pin	971A172Y	Fixed contact cluster	971A148	Contact housing	971A148	Moving Contact Complet	971A287	Tanks stable	971A253
	971A477Y	QNRO						Vent locking plate	971A168			Spring retainer	971A141				
								Vent	971A171			Arcing contact	971A133				
								Thrust washer	971A175			Contact	971A139Y				
								Screw	3229A6			Retaining clip	971A142				
												Fixed contact	971A135Y				
												Spring	3240A62				
LM72	971A709Y	QNRO	1250A System Volts Up to 12kV Insulated For 13.8 kV 25kA at 12kV 2 secs 20kA at 12kV 3 secs Pressure less 42kV for 1 min	X30	Turbulator Cpte	971A244Y	3	Turbulator pin	971A172Y	Fixed contact cluster	971A237	Contact housing	971A236	Moving Contact Complet	971A284	Tanks stable	971A253
								Vent locking plate	971A168			Spring retainer	971A141				
								Vent	971A171			Arcing contact	971A213				
								Thrust washer	971A375			Contact	971A214				
								Screw	3229A6			Retaining plate	971A234X				
												Fixed contact	971A231				
												Spring	3240A62				

LMT1

Description	Voltage	Article No	No per Panel
Trip Coil	24V dc	865A424Y	1
Trip Coil	30V dc	865A1287	1
Trip Coil	50V dc 110V ac	865A402Y	1
Trip Coil	110/125V dc 220/250V ac	865A295Y	1
Trip Coil	230/240V dc	865A547W	1
Trip Coil	1.25 Amps	865A1610	1
Trip Coil	2 Amps	865A1287	1
Trip Coil	2.5 Amps	865A417Y	1
Trip Coil	5 Amps	865A1289	1
Close Coil	24V dc	865A424Y	1
Close Coil	30V dc	865A1287	1
Close Coil	50V dc 110V ac	865A402Y	1
Close Coil	110/125V dc 220/250V ac	865A295Y	1
Close Coil	230/240V dc	865A547W	1

Dashpot Washer	861A235Y	1 per LM23T	2 per LM36T

VT HV Fuses	All Circuit Breakers. LMT1 & 2	297A327

LMT2

Description	Voltage	Article No	No per Panel
Trip Coil	24V dc	975A559Y	1
Trip Coil	30V dc	975A284Y	1
Trip Coil	50V dc 110V ac	975A421Y	1
Trip Coil	110V dc 240V ac	975A286Y	1
Trip Coil	220/240V dc	975A330X	1
Trip Coil	1.25 Amps	975A374Y	1
Trip Coil	2 Amps	975A877	1
Trip Coil	5 Amps	975A837Y	1
Trip Coil	24V dc	975A559Y	1
Close Coil	30V dc	975A284Y	1
Close Coil	50V dc 110V ac	974A421Y	1
Close Coil	110V dc 240V ac	975A286Y	1
Close Coil	230/240V dc	975A330X	1

Appendix 3 – Site issues

LM23T – The original dashpot buffer washer fitted to LM23T, LM36T and LMI circuit breakers must be changed in line with SOP 206.
The change is necessary because the original buffer washer was manufactured using PVC, which can deteriorate with age when submerged in oil.
The breaking up of the washer through this process can result in dashpot seizure. This of course can be disastrous under fault conditions.
A new washer manufactured from nitrile rubber (861A235Y) is available.
This problem does not effect LMT2

Appendix 4 – Retrofit