TELEDYNE TEST SERVICES
Everywhereyoulook™
Valve Diagnostic Testing and Maintenance

Seventh Annual QUIKLOOK Users Group Meeting

August 14 & 15, 2013

Presented by: Mike Richard

TELEDYNE TEST SERVICES
Everywhereyoulook™
Valve Diagnostic Testing and Maintenance

MIDAS

Implementation of LTU 93-03

Manager Computer Interaction
Michael Richard

Technical Discussion

How does your plant/utility use Limitorque Technical Update 93-03 in determining MOV torque capability? Does your plant take credit for a lower current associated with elevated temperatures? If yes, is the current loss based on 25°C or 40°C? What temperature is the torque de-rate based on, i.e. 25°C or 40°C? Does your plant analyze motor capability at nominal temperature and/or maximum temperature?

Limitorque 93-03

Limitorque Corporation

Automated Valve Actuators and Jacks for Industry

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Telephone (804) 528-4400 • FAX (804) 845-9736

LIMITORQUE TECHNICAL UPDATE - 93-03

SUBJECT: **Reliance 3-Phase Limitorque Corporation Actuator Motors (Starting Torque @ Elevated Temperature)**

REFERENCE: **Potential 10CFR21 Condition Dated May 13, 1993 (Attached)**

Issued September, 1993

The purpose of this update is to provide guidance in addressing the referenced document.

1. **550/575 Volt 3-Phase** - The tabulated data presented in the referenced document is applicable to 550/575 volt, 3-Phase Reliance motors.

2. **Motor Applicability** - The tabulated data presented in the referenced document is applicable to all Reliance 3-phase motors. The motor start torque, no-load speed, and frame size must match that given in the tabulation, e.g.:
   Existing Reliance 230/460, 3-phase, 60 Hz, 100 '#, 1800 RPM, 210 Frame motor design curve unavailable. From the tabulation, percent current loss is 17.8 percent, and percent torque loss is 13.1 percent when subjected to a 155°C increase in temperature.

3. **Deration Start Temperature** - The torque reduction is to be applied at temperatures >40°C (104°F). The tabulation details percent loss over a 155°C change in temperature (i.e., from 25° C to 180° C). The percent torque loss per °C for a 10'#, 1800 RPM, 56 Frame motor is:

   $$\frac{27.7\%}{155°C} = 0.179\% / °C$$

   The percent torque loss for this motor operating in 100°C ambient is:
   (0.179%) (100°C - 40°C) = 10.7%

4. **Temperature Rise With Motor Energized** - Reliance 3-phase motors are designed with thermal characteristics that result in ≤75°C temperature rise in:
   a) 15 minutes @ full load running torque.

b) 10 seconds @ locked rotor.

A typical valve stroke time of 30 seconds will increase the motor temperature as follows:

$$\underset{\text{Time for full load stroke}}{(.5\ \text{Min})} \times \frac{\overset{\text{Temperature rise rate during running}}{75°C}}{15\ \text{Min.}} + \underset{\text{Time for starting motor}}{0.1\ \text{Sec}} \times \frac{\overset{\text{Temperature rise rate during starting}}{(75°C)}}{(10\ \text{Sec})} = 3.25°C$$

Rise in one stroke

The above example is simplistic and is given only to show that the motor temperature rise associated with stroking the valve is insignificant.
However, applications that allow the motor to draw locked rotor current until the system or valve stabilizes must be addressed. A 5 second duration at locked rotor current will result in a temperature increase of ≤ 37.5°C.
It should be noted that continual diagnostic testing will increase motor temperature and decrease output torque and thrust.

5. **Motor Speed at Elevated Temperature** - Elevated temperature will reduce the motor full load speed. The speed reduction is minimal (≈2% or 3%) from 25°C to 180°C.

6. **Limitorque Corporation Sizing Equation** - The standard sizing equation requires the use of a 0.9 application factor. If the motor terminal voltage is less than 90 percent, this factor may be revised to 1.0. As before, there is no reduced voltage factor down to 90% voltage but below 90% voltage the square of the percent voltage available to rated motor voltage must be applied.

7. **Misprint in Referenced Document** - The 2'#, 1800 RPM, 56 Frame motor of the tabulation is a **48** frame motor.

8. **Additional Motor Data:**

Start/RPM/Frame	% Current Loss	% Torque Loss
1'# / 900 / 48	30% / 155°C	19% / 155°C
2'# / 900 / 48	30% / 155°C	19% / 155°C
175'# / 3600 / 256	16.7% / 155°C	9.9% / 155°C
150'#/ 1800 / 256	15% / 155° C	12% / 155° C

P. McQuillan
Nuclear/ Special Projects Manager

Limitorque 93-03

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May 13, 1993

U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Attention: Document Control Desk

Re: Potential 10 CFR 21 Condition

Subject: Reliance 3Ø
L. C. Actuator Motors
(Starting Torque at Elevated Temperature)

Limitorque Corporation has completed an evaluation of the subject motors. The results of this evaluation should be utilized to determine actuator operability at motor temperatures of 25° C through 180° C. The motor starting torque decreases with increasing temperature thereby decreasing actuator output torque. This condition could potentially be reportable depending on the operating practice of the licensee. Therefore, pursuant to the requirement of 10 CFR Part 21, herein provided is notification of a potential defect in Limitorque Corporation supplied motor actuators or motors supplied as spare parts.

Identification of Basic Component

The affected component is the Reliance 3Ø A.C. motor that provides input power to actuator types SMB/SB/SBD 000 through 5 and SMB 000 through 5/HBC 0 through 7 combinations.

Discovery Date

The discovery date of this potential defect was July 27, 1989.

Nature of the Defect

The electrical characteristics of the Reliance 3Ø A.C. Limitorque Corporation valve actuator motor are temperature dependent and locked rotor torque and locked rotor amperage will vary with motor temperature. Typically locked rotor torque and locked rotor amperage decrease as motor temperature increases. The attached tabulation details both parameters percentage changes in the temperature range of 25° C to 180° C. The percentage change is linear with respect to temperature for both parameters with baseline data at 25° C.

The tabulation provides data that is relevant to standard Limitorque Corporation motor designs. The user must ensure that the motor performance curve number shown on the tabulation (e.g. M2735A) is applicable to the motor that is undergoing analysis. If this data is not available, the licensee may furnish the applicable motor identification numbers to Limitorque Corporation in order to make this determination.

The following guidance is offered:

1. Credit should be taken for the locked rotor amperage decrease which will result in a higher available motor terminal voltage.
2. Motor temperature rise due to prior motor energization and motor run time (valve stroke time) must be accounted for.
3. The tabulated data is expected to also predict 550/575 V 3Ø 15 minute duty motor performance. The starting torque rating, no load speed and frame size of the 550/575V motor must match the attached data to allow this analysis. The licensee is requested to provide the motor identification numbers to Limitorque Corporation to verify this assumption.
4. The tabulated data is based on analysis by Reliance Electric. Limitorque Corporation performed testing on two motor designs (quantity of 5 motors) which validated the analysis.

Equipment Affected

1. Same as the basic component identification.
2. Previously supplied technical data that may be used as the basis for operability justification. Where applicable this data should be revised to account for the applicable elevated temperature effects.

Licensee Corrective Action

Ensure operability justification considers the effect of motor performance at the applicable motor temperature.

Limitorque Corporation Corrective Action

Revise the selection procedure for safety related actuators, motors, and technical data packages to account for motor performance at the applicable motor temperature.

Limitorque 93-03

A copy of this notification has been sent to the Nuclear Regulatory Commission (NRC) under a separate cover letter.

Any questions or clarifications regarding the above notification may be directed to P. McQuillan, Nuclear/Special Projects Manager at (804)528-4400 Ext. 714.

Signed:

T. E. Wilkinson
Vice-President of Engineering

Attachment

cc: T. Mignogna
Part 21 Notification File

Current/Torque Changes from 25 to 180 Centigrade

Start/RPM	Frame	Curve #	% Current Loss	% Torq Loss
2'#/1800	56	M2735A	27.8%	20.7%
5'#/1800	48	M2734	29.0%	18.6%
5'#/1800	56	M1658	21.8%	21.9%
7.5'#/1800	56	M2925	22.4%	5.7%
10'#/1800	56	M1468	26.9%	27.7%
15'#/1800	56	M1476	23.7%	23.1%
25'#/1800	56	M1480	23.1%	23.2%
40'#/1800	56	M1488	21.1%	23.4%
60'#/1800	56	M5204	20.8%	20.9%
60'#/1800	180	SK-59454	19.6%	18.2%
80'#/1800	210	SK-59423	16.1%	15.8%
100'#/1800	210	SK-59419A	17.0%	13.1%
200'#/1800	256	SK-34177	13.5%	9.0%
250'#/1800	256	SK-34193	11.8%	6.9%
300'#/1800	326	SK-34183	11.7%	5.8%
2'#/3600	48	413018-03	28.3%	16.0%
5'#/3600	48	M199	27.7%	18.5%
5'#/3600	56	M1454	24.7%	26.8%
7.5'#/3600	56	M1457	27.6%	16.7%
10'#/3600	56	M1458	23.5%	30.8%
15'#/3600	56	M1460	19.2%	21.4%
25'#/3600	56	M1463	16.2%	24.1%
40'#/3600	56	M4635	27.9%	15.9%
40'#/3600	180	SK-59450	16.2%	11.8%
60'#/3600	210	SK-59446	18.2%	16.5%
80'#/3600	210	SK-59448	18.0%	18.3%
100'#/3600	256	SK-34176	14.1%	9.8%
150'#/3600	256	SK-34184	13.9%	10.0%
200'#/3600	326	SK-34188	10.5%	3.4%
250'#/3600	326	SK-34173	9.3%	3.4%
300'#/3600	326	SK-34171	10.8%	2.9%
400'#/3600	365	SK-34800-	8.8%	-1.8%

Motor Torque Methodology in MIDAS

LIMITORQUE MOTOR PULLOUT TORQUE EQUATION (MPT)

$$MPT = MST * OAR * PE * AF * (V_{mt} / V_{rated})^2 * TRF$$

Where:

MST	= Motor Start Torque
OAR	= Overall Actuator Ratio
PE	= Gear Efficiency at Pullout
AF	= Application Factor (Generally 0.9 Ref: SEL. - 4)
V_{mt}	= Terminal Voltage at Motor (see NOTE 1)
TRF	= Torque Reduction Factor (based on elevated temperature)
V_{rated}	= Motor Rated Voltage

NOTE 1: The V_{mt} / V_{rated} term is only included when V_{mt} is less than 90% of V_{rated} and this equation is not valid if V_{mt} is less than 70% of V_{rated}.

NOTE 2: Actuators that fall in the following categories will require an additional allowance per Limitorque Technical Update 05-01.

a) Unit with a 25 ft-lb, 3600 rpm motor in a 56 frame. (change exponent to 2.5)
b) Unit with a 60 ft-lb, 1800 rpm motor in a 56 frame. (10% reduction)
c) SMB-1 units with a 66:1 worm gear ratio. (10% reduction)

$$TRF = 1 - \left[TL\% \times \frac{T_2 - 40^\circ C}{180^\circ C - 25^\circ C} \right]$$

Where:

TL%	=	The percent torque loss from Limitorque Technical Update 93-03 for the appropriate motor, frame size, and RPM.
T_2	=	The ambient temperature (°C) assumed in calculating the available voltage.

Voltage Drop Analysis in MIDAS

The Motor Terminal Voltage for AC Motors will be determined by using the Voltage Divider Method as described below:

(a) Motor Terminal Voltage

$$Vmt = \frac{(Zmotor)\ x\ (Vmcc)}{\sqrt{(Rmotor + Rcable + Rtol)^2 + (Xmotor + Xcable)^2}}$$

Where:

V_{mt}	=	Voltage at Motor Terminals
V_{mcc}	=	Voltage at Motor Control Center Feeder Breaker
Z_{motor}	=	Motor Impedance
R_{motor}	=	Motor Resistance
R_{cable}	=	Cable Resistance
R_{tol}	=	Thermal Overload/Fuse Resistance + Tolerance
X_{motor}	=	Motor Reactance
X_{cable}	=	Cable Reactance

(b) Motor Impedance (Z_{motor})

$$Z_{motor} = \frac{V_{rated}}{\sqrt{3} \times LRA \times \left(1 - CL\% \frac{(T_{amb} - T_{rate})}{155\,°C}\right)}$$

Where:

LRA	=	Rated Motor Locked Rotor Amps
V_{rated}	=	Rated Motor Voltage
T_{amb}	=	Maximum Motor Ambient Operating Temperature (°C)
T_{rate}	=	Motor Rated Operating Temperature (°C)
CL%	=	% Current Loss from 25°C to 180°C

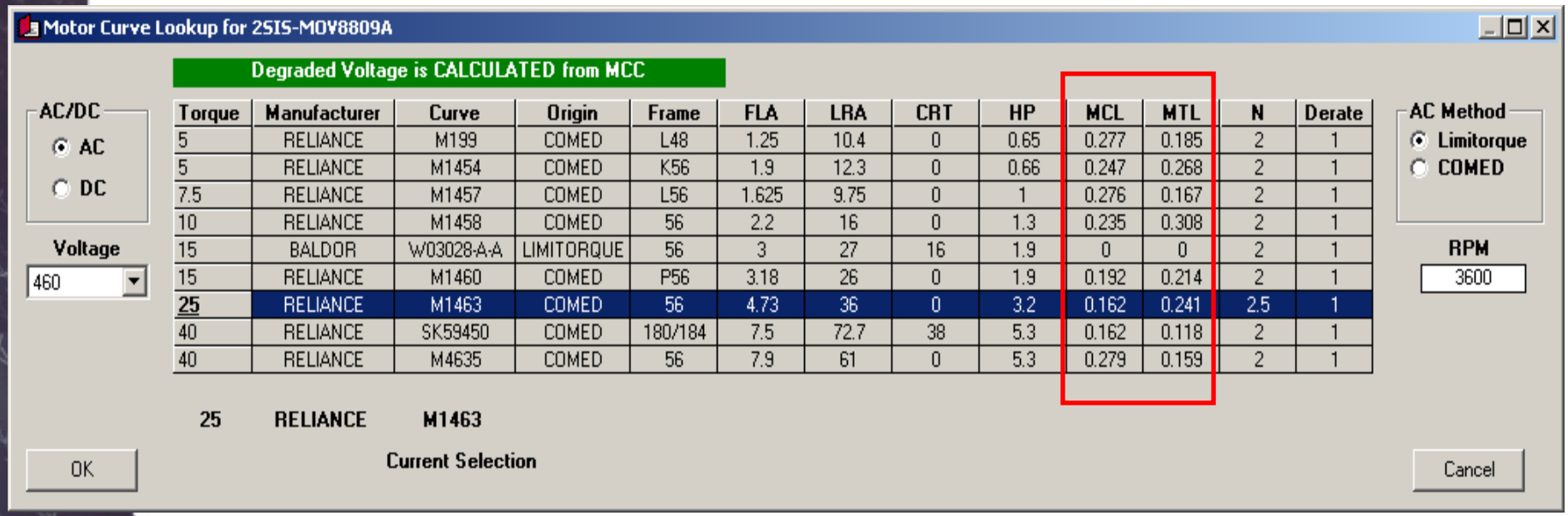
MIDAS Implementation

Motor Lookup Table

Motor Curve=M1463

MCL=%motor current loss=0.162%

MTL=%motor torque loss=0.241%



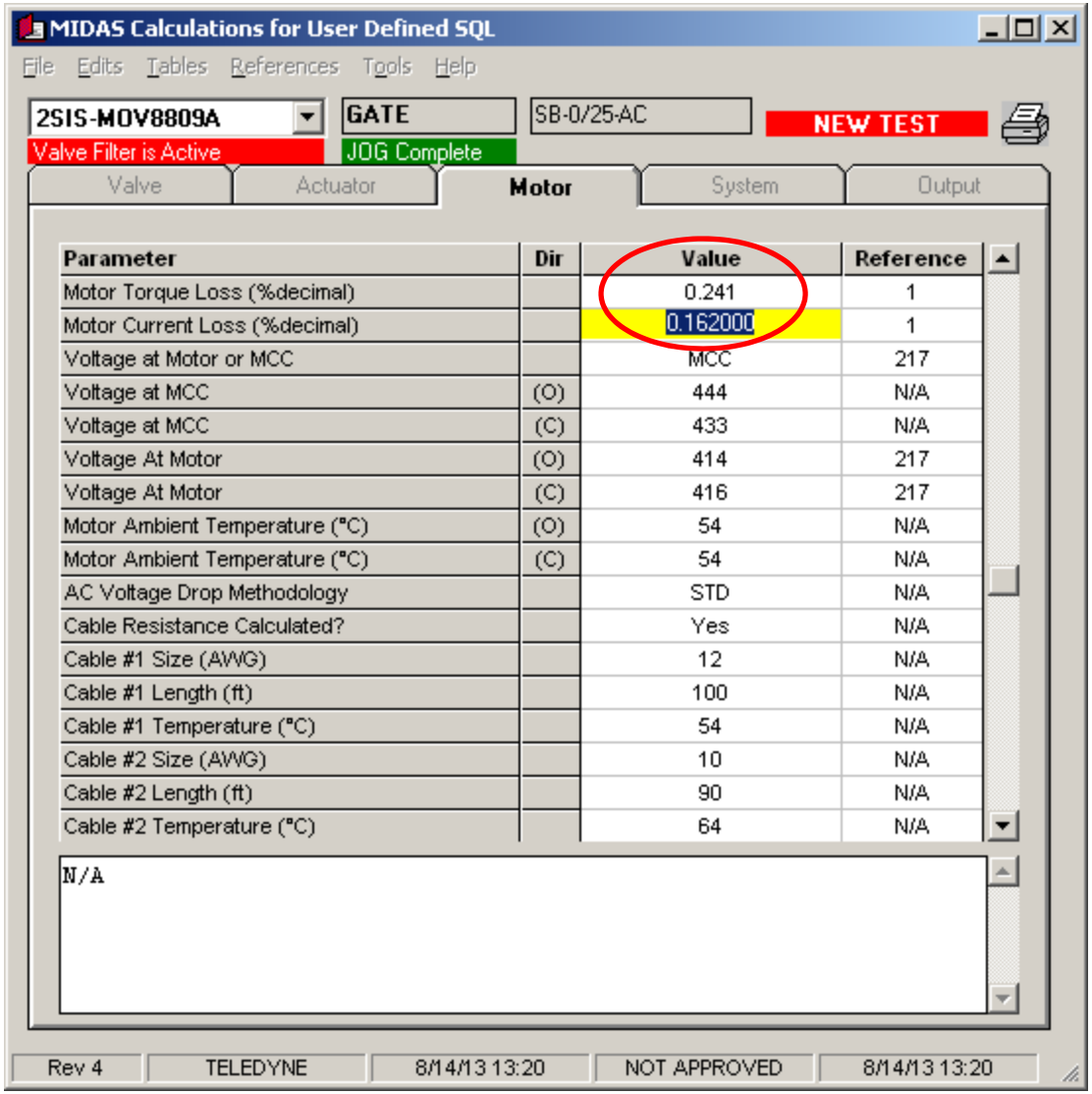
Torque	Manufacturer	Curve	Origin	Frame	FLA	LRA	CRT	HP	MCL	MTL	N	Derate
5	RELIANCE	M199	COMED	L48	1.25	10.4	0	0.65	0.277	0.185	2	1
5	RELIANCE	M1454	COMED	K56	1.9	12.3	0	0.66	0.247	0.268	2	1
7.5	RELIANCE	M1457	COMED	L56	1.625	9.75	0	1	0.276	0.167	2	1
10	RELIANCE	M1458	COMED	56	2.2	16	0	1.3	0.235	0.308	2	1
15	BALDOR	W03028-A-A	LIMITORQUE	56	3	27	16	1.9	0	0	2	1
15	RELIANCE	M1460	COMED	P56	3.18	26	0	1.9	0.192	0.214	2	1
25	RELIANCE	M1463	COMED	56	4.73	36	0	3.2	0.162	0.241	2.5	1
40	RELIANCE	SK59450	COMED	180/184	7.5	72.7	38	5.3	0.162	0.118	2	1
40	RELIANCE	M4635	COMED	56	7.9	61	0	5.3	0.279	0.159	2	1

MIDAS Implementation

Motor Tab

MCL=0.162%

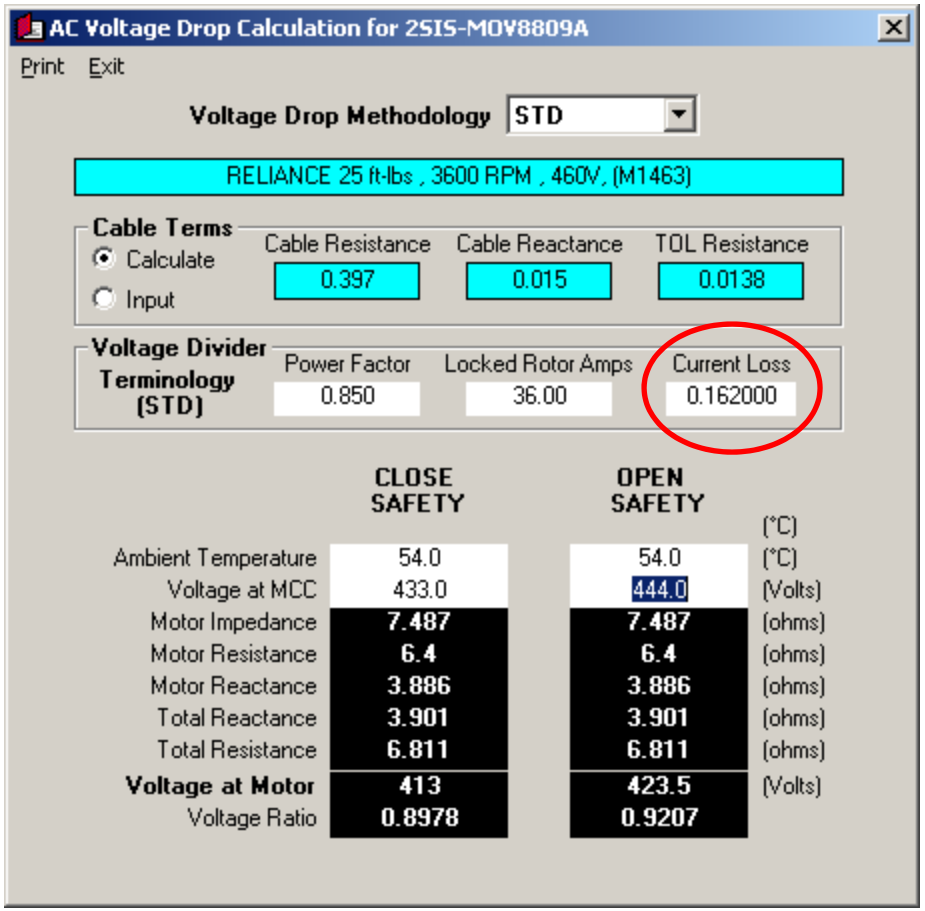
MTL=0.241%



MIDAS Implementation

Voltage Drop Table

MCL=0.162%



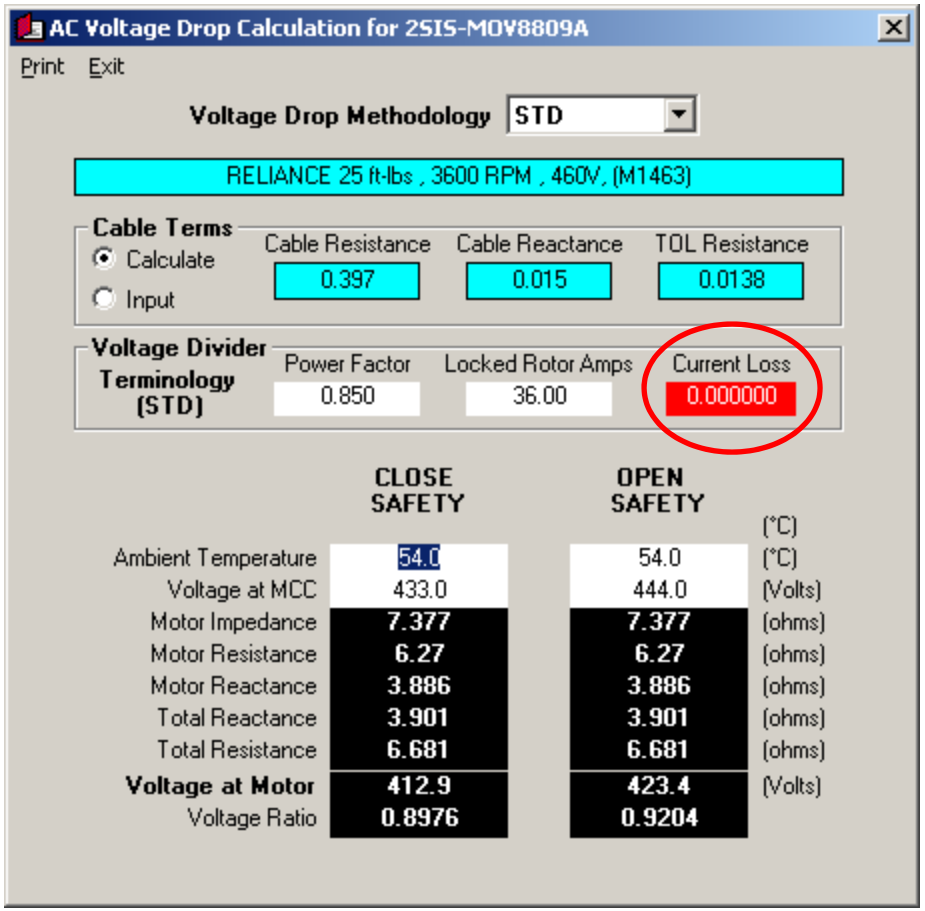
MIDAS Implementation

Voltage Drop Table

MCL=0

For

Conservatism



MIDAS Implementation

Degraded Motor Torque Difference for MCL=0

List Edits for 2SIS-MOV8809A

Print Exit

Input | Output | References

Parameter	Direction	WIP	New Value	%Change
Motor Impedance (ohms)	open	7.487	7.377	-1.5
Motor Impedance (ohms)	close	7.487	7.377	-1.5
Motor Resistance (ohms)	open	6.4	6.27	-2.0
Motor Resistance (ohms)	close	6.4	6.27	-2.0
Total Resistance (ohms)	open	6.811	6.681	-1.9
Total Resistance (ohms)	close	6.811	6.681	-1.9
Motor Terminal Voltage (volts)	open	423.5	423.4	-0.02
Motor Terminal Voltage (volts)	close	413	412.9	-0.02
Motor Terminal Voltage Ratio (%decimal)	open	0.9207	0.9204	-0.03
Motor Terminal Voltage Ratio (%decimal)	close	0.8978	0.8976	-0.02
Degraded Voltage Loss	close	0.7638	0.7633	-0.07
Motor Derate Factor	close	0.7471	0.7467	-0.05
Motor Torque @Degraded Voltage (ft-lbs)	close	18.68	18.67	-0.05
Actuator Torque @Degraded Voltage (ft-lbs)	close	264.5	264.3	-0.08
Actuator Torque wrt Safety Function (ft-lbs)	close	264.5	264.3	-0.08
Actuator TQ wrt Safety Fun. @VLV (ft-lbs)	close	264.5	264.3	-0.08

VMP | TELEDYNE | 8/14/13 13:20 | NOT APPROVED | 8/14/13 13:20

MIDAS Implementation

MCL

Voltage Drop Report

Motor Impedance

Open: $Z_{motor,o} = (V_{rated}) / [(3)^{1/2} * (LRA) * (1 - (MCL * (MxAmbTo - 40) / 155)]$
$= (460) / [(3)^{1/2} * 36) * (1 - (0.162 * (54 - 40) / 155)] =$ **7.487** ohms

Close: $Z_{motor,c} = (V_{rated}) / [(3)^{1/2} * (LRA) * (1 - (MCL * (MxAmbTc - 40) / 155)]$
$= (460) / [(3)^{1/2} * 36) * (1 - (0.162 * (54 - 40) / 155)] =$ **7.487** ohms

Motor Reactance

$X_{motor} = (V_{rated} * \sin(\arccos(PF)) / [(3)^{1/2} * (LRA)]$
$= (460 * \sin(\arccos(0.85)) / [(3)^{1/2} * (36)] =$ **3.886** ohms

Motor Resistance

Open: $R_{motor,o} = [(Z_{motor,o})^2 - (X_{motor})^2]^{1/2}$
$= [(7.487)^2 - (3.886)^2]^{1/2} =$ **6.4** ohms

Close: $R_{motor,c} = [(Z_{motor,c})^2 - (X_{motor})^2]^{1/2}$
$= [(7.487)^2 - (3.886)^2]^{1/2} =$ **6.4** ohms

Motor Terminal Voltage

Open: $V_{mt,o} = (Z_{motor,o} * V_{mcc,o}) / [(R_{motor,o} + R_{cable} + R_{tol})^2 + (X_{motor} + X_{cable})^2]^{1/2}$
$= (7.487 * 444) / [(6.4 + 0.397 + 0.0138)^2 + (3.886 + 0.015)^2]^{1/2}$
$=$ **423.5** Vac

Close: $V_{mt,c} = (Z_{motor,c} * V_{mcc,c}) / [(R_{motor,c} + R_{cable} + R_{tol})^2 + (X_{motor} + X_{cable})^2]^{1/2}$
$= (7.487 * 433) / [(6.4 + 0.397 + 0.0138)^2 + (3.886 + 0.015)^2]^{1/2}$
$=$ **413** Vac

Motor Terminal Voltage Ratio

Open: $V_{min,o} = (V_{mt,o} / V_{rated}) = (423.5 / 460) =$ **0.9207**

Close: $V_{min,c} = (V_{mt,c} / V_{rated}) = (413 / 460) =$ **0.8978**

MIDAS Implementation

Degraded Torque Report

AC Motor Torque Calculation

Limitorque Method: Degraded Voltage Loss = 1 for Degraded Voltage >= 90% of Rated Voltage.

Close Degraded Voltage Loss = (1 * 413 / 460)^{N} = **0.7638** **Limitorque Method**

Open Degraded Voltage Loss = (1 * 423.5 / 460)^{N} = **1** **N = 2.5**

$$\text{Temperature Loss} = 1 - \frac{\text{Torque Loss} * (\text{Ambient Temp} - 40)}{155}$$

NOTE: For (Ambient Temp - 40) < 0 Use Temperature Loss = 1 for conservatism.

$$\text{Close Temperature Loss} = 1 - \frac{0.241 * (54 - 40)}{155} = \mathbf{0.9782}$$

$$\text{Open Temperature Loss} = 1 - \frac{0.241 * (54 - 40)}{155} = \mathbf{0.9782}$$

MTL

Motor Derate Factor = Degraded Voltage Loss * Temperature Loss * LTU Derate Factor

Close Motor Derate Factor = 0.7638 * 0.9782 * 1 = **0.7471**

Open Motor Derate Factor = 1 * 0.9782 * 1 = **0.9782**

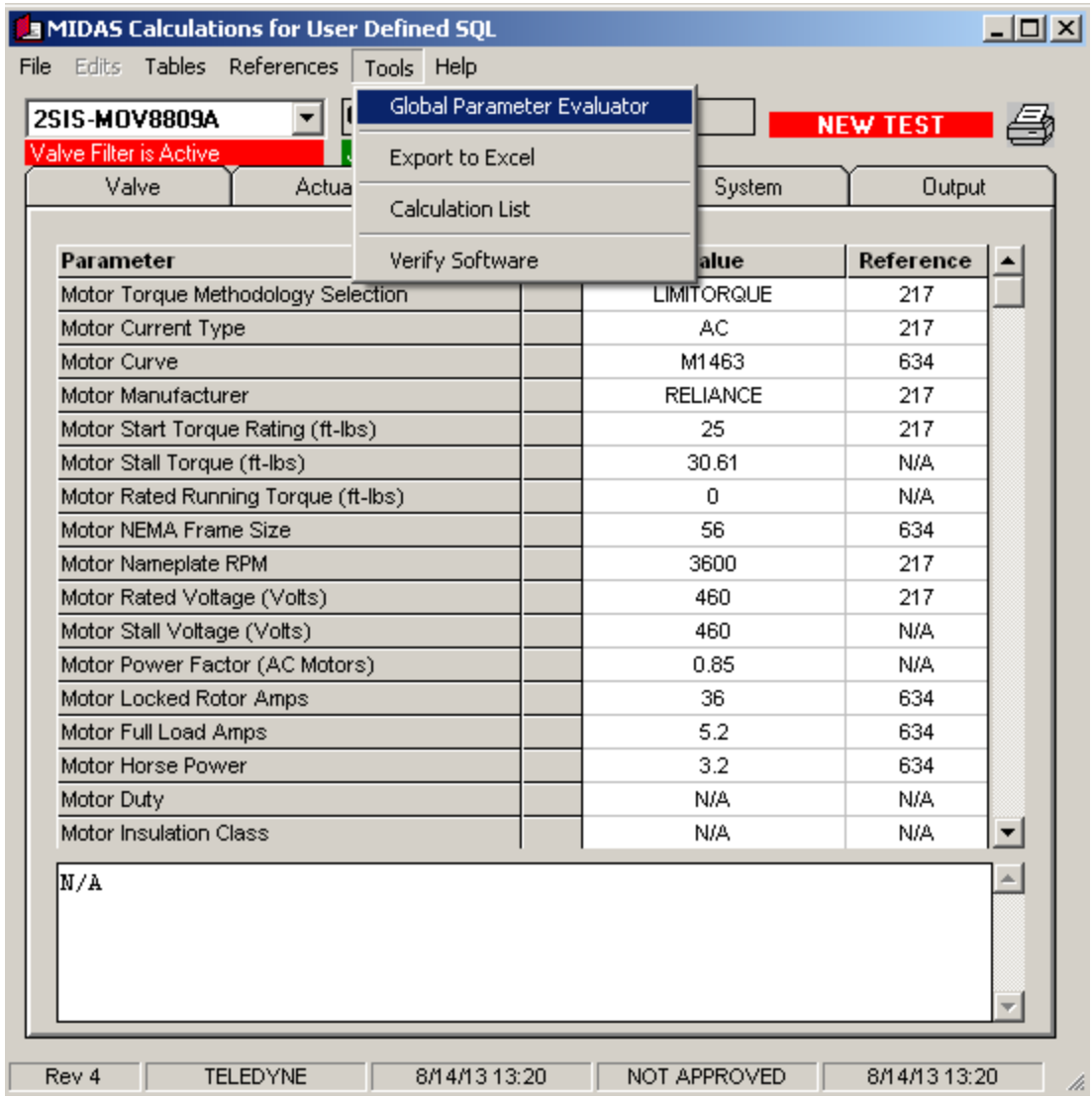
Motor Derated Torque = Motor Start Torque * Motor Derate Factor

Close Motor Derated Torque = 25 * 0.7471 * 1 = **18.68** **ft-lbs**

Open Motor Derated Torque = 25 * 0.9782 * 1 = **24.46** **ft-lbs**

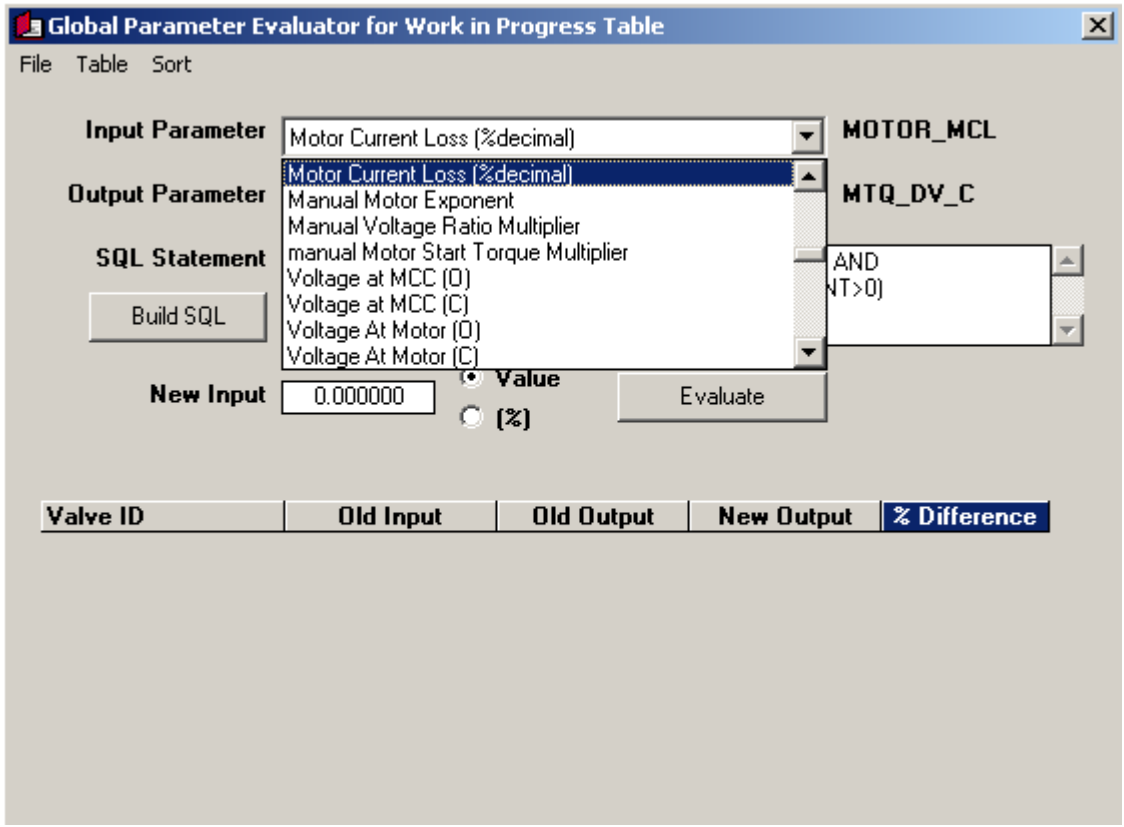
MIDAS Implementation

Global Parameter Evaluator Tool



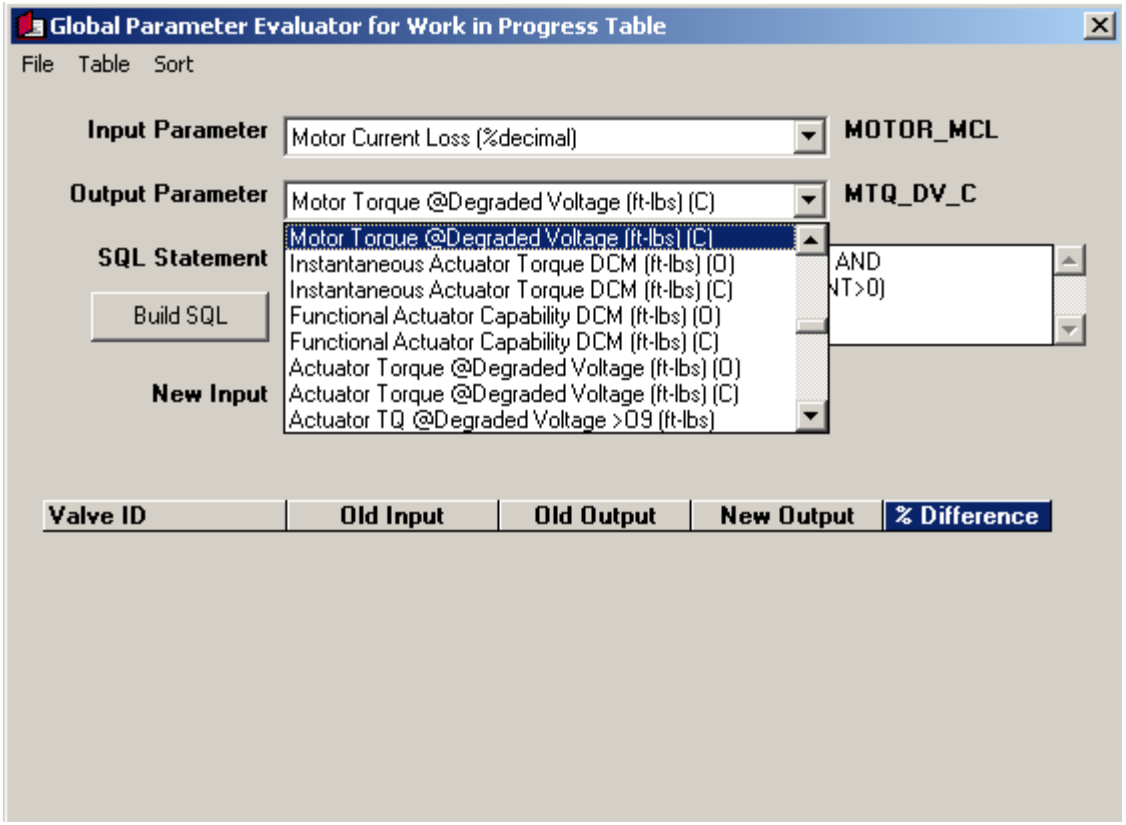
MIDAS Implementation

Global Parameter Evaluator Setup - Input



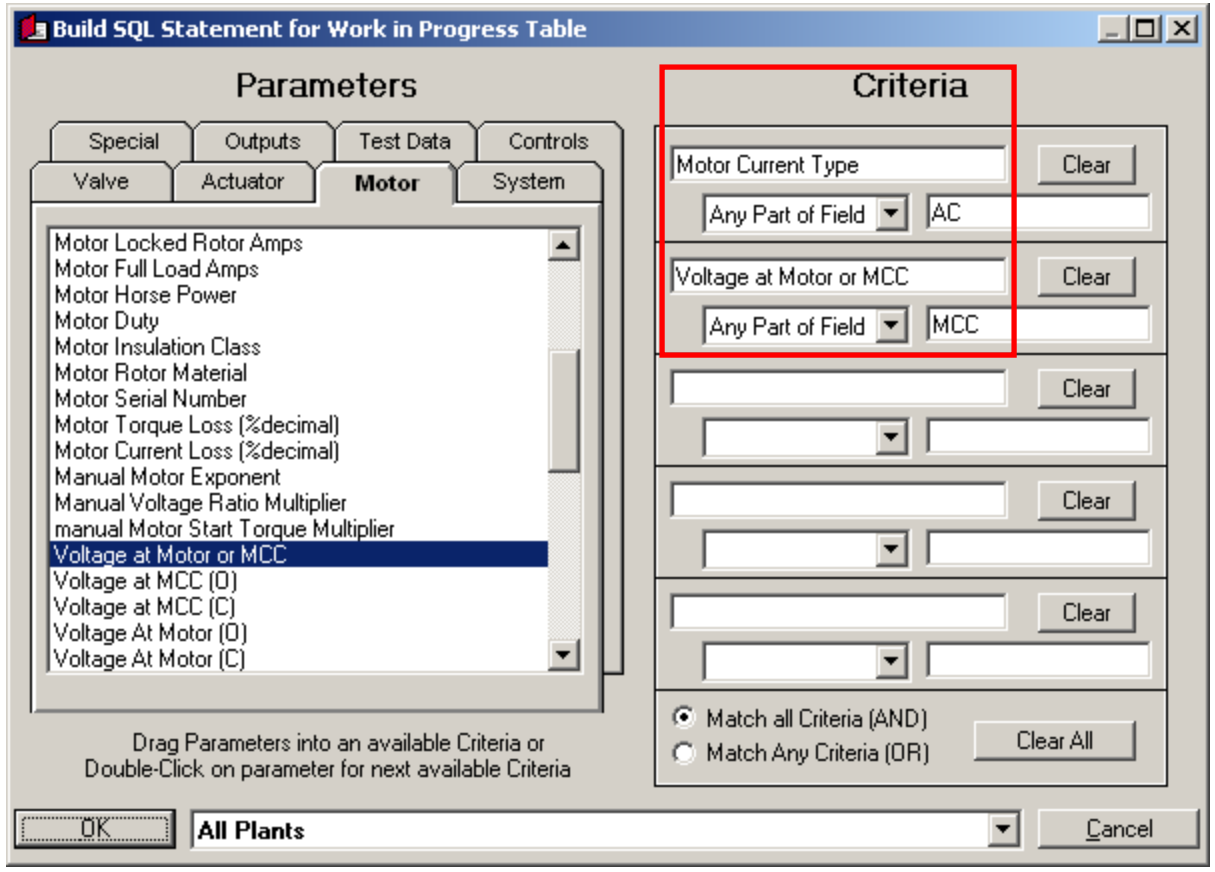
MIDAS Implementation

Global Parameter Evaluator Setup - Output



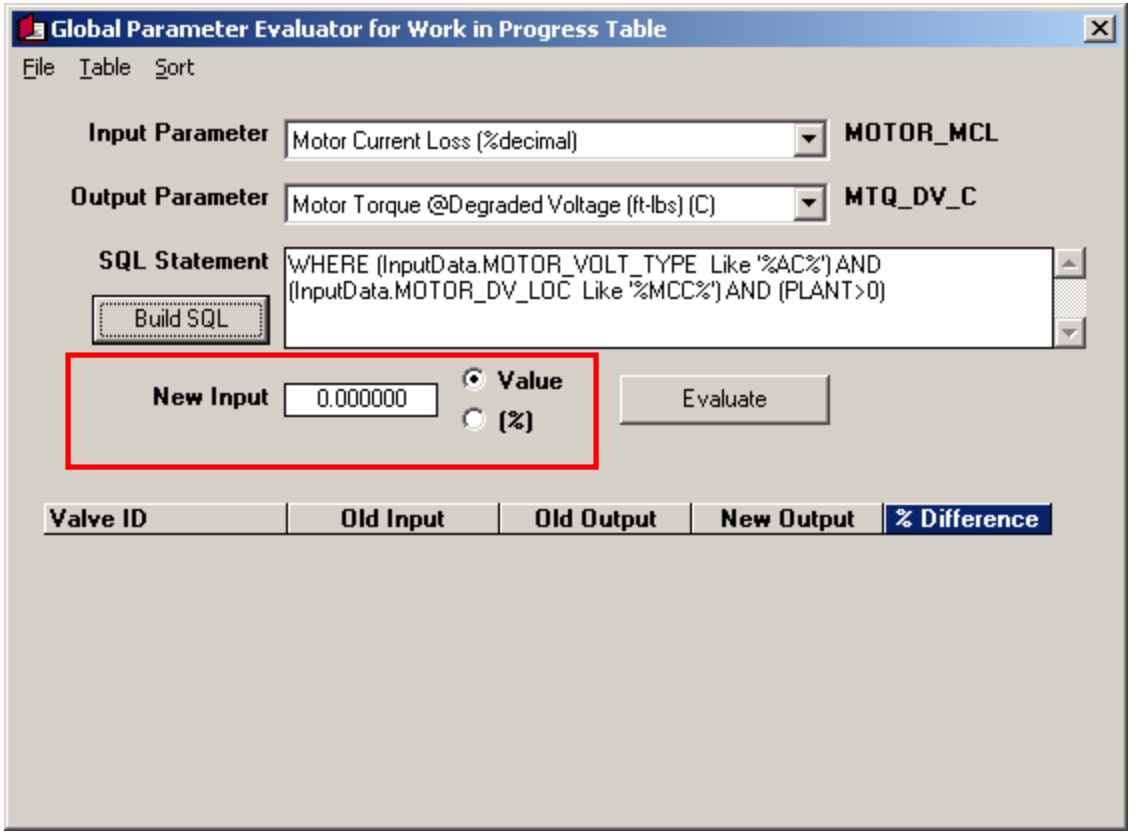
MIDAS Implementation

Global Parameter Evaluator Setup - Criteria



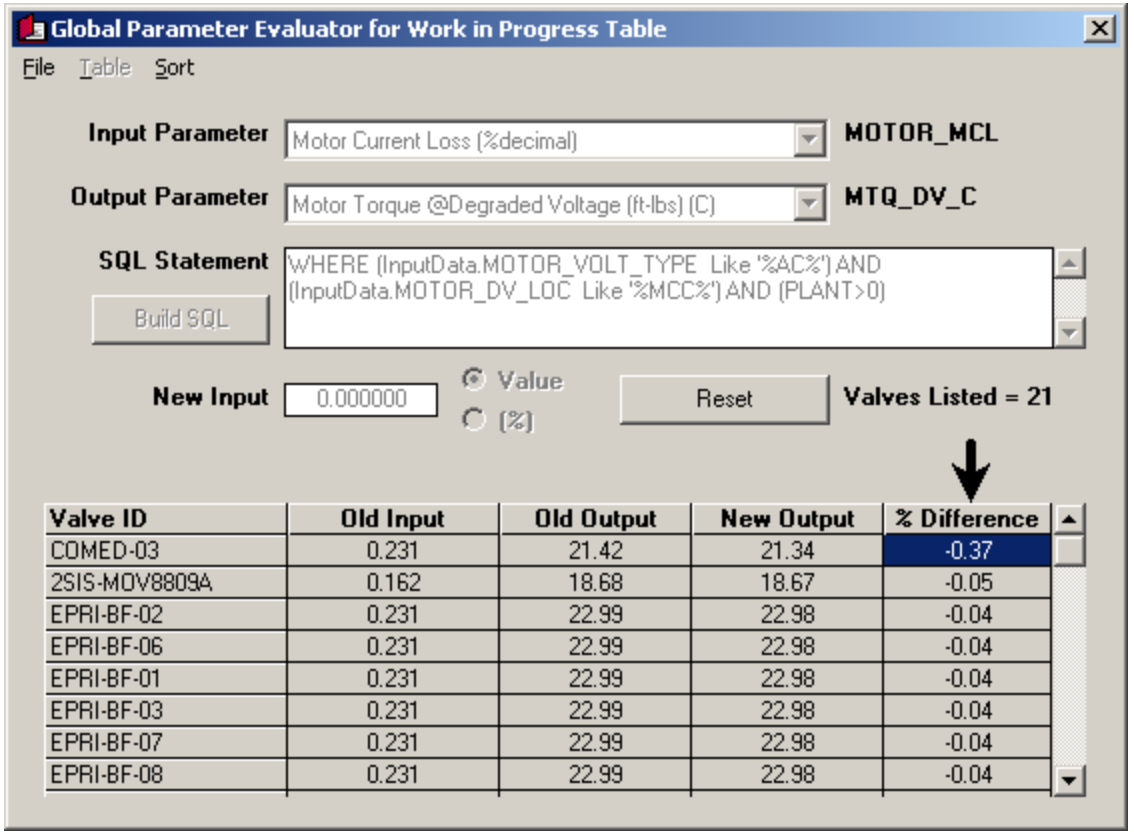
MIDAS Implementation

Global Parameter Evaluator Setup - Value



MIDAS Implementation

Global Parameter Evaluator - Results



Valve ID	Old Input	Old Output	New Output	% Difference
COMED-03	0.231	21.42	21.34	-0.37
2SIS-MOV8809A	0.162	18.68	18.67	-0.05
EPRI-BF-02	0.231	22.99	22.98	-0.04
EPRI-BF-06	0.231	22.99	22.98	-0.04
EPRI-BF-01	0.231	22.99	22.98	-0.04
EPRI-BF-03	0.231	22.99	22.98	-0.04
EPRI-BF-07	0.231	22.99	22.98	-0.04
EPRI-BF-08	0.231	22.99	22.98	-0.04

MIDAS Implementation

Global Parameter Evaluator - Report

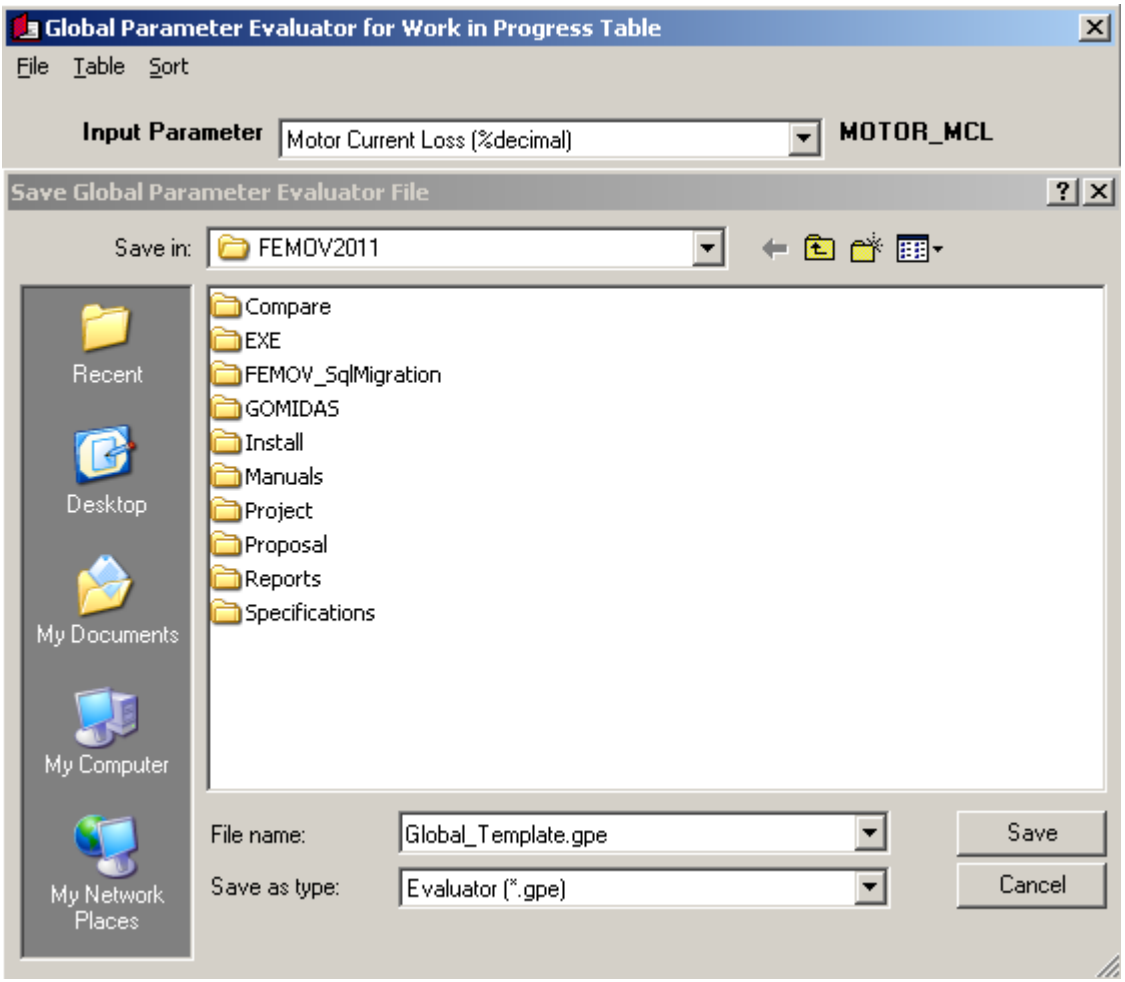
FirstEnergy

Global Parameter Evaluator for Work in Progress Table
Input: Motor Current Loss (%decimal) = 0.000000
Output: Motor Torque @Degraded Voltage (ft-lbs) (C)
Sorted By: %Difference Ascending
SQL: WHERE (InputData.MOTOR_VOLT_TYPE Like '%AC%') AND (InputData.MOTOR_DV_LOC Like '%MCC%'

Valve Identification	Old Input	Old Output	New Output	Change %
COMED-03	0.231	21.42	21.34	-0.37
2SIS-MOV8809A	0.162	18.68	18.67	-0.05
EPRI-BF-02	0.231	22.99	22.98	-0.04
EPRI-BF-06	0.231	22.99	22.98	-0.04
EPRI-BF-01	0.231	22.99	22.98	-0.04
EPRI-BF-03	0.231	22.99	22.98	-0.04
EPRI-BF-07	0.231	22.99	22.98	-0.04
EPRI-BF-08	0.231	22.99	22.98	-0.04
EPRI-BF-04	0.231	22.99	22.98	-0.04
EPRI-BF-10	0.231	22.99	22.98	-0.04
EPRI-BF-09	0.231	22.99	22.98	-0.04
EPRI-BF-05	0.231	22.99	22.98	-0.04
HP31	0.269	8.94	8.94	0.00
2CCP-MOV150-1	0.29	4.97	4.97	0.00
COMED-02	0.269	10.07	10.07	0.00
2SIS-MOV8809-X	0.162	24.46	24.46	0.00
CF2A	0.29	4.11	4.11	0.00
COMED-01 COPY	0.208	37.55	37.55	0.00
COMED-01	0.208	37.55	37.55	0.00
HP31-M	0	0	0	Infinite
Rotork-01	0	0	0	Infinite

MIDAS Implementation

Global Parameter Evaluator – Save Template



MIDAS Implementation

Questions?