Generator Testing

Standard Tests

- Winding resistance
- Insulation resistance
- Hi-pot all windings
- Open circuit saturation curve
- Voltage and current balance of windings
- Voltage transient at rated kVA 0.0 P.F.
- Voltage regulation and regulator adjust range
- Phase sequence
- Mechanical balance
- Options (RTDs, space heaters…)

Standard Test Sheet

KATO ENGINEERING

T.A. 7 (3.0.9)

SYNCHRONOUS MACHINE COMMERCIAL TEST

KW	KVA	P.F.	RPM	PHASE	FREQ.	VOLTS	AMPS	SERIAL NUMBER	UNIT
3200	4000	0.8	1500	3	50	6300	366	12345	1
CUSTOMER:	VALUED KATO CUSTOMER XYZ								

DATE
2/15/2014

RESISTANCE CORRECTED TO 25 deg. C						
ARM 1-2	0.0603550	Ω		GEN. FLD.	0.3144	Ω
ARM. 2-3	0.0604200	Ω		EXC. FLD.	19.273	Ω
ARM. 3-1	0.0605050	Ω	(1)	EXC. ARM. 1-2	0.010675	Ω
WATTLOW		Ω		EXC. ARM. 2-3	0.010665	Ω
		Ω		EXC. ARM. 3-1	0.010487	Ω
		Ω		PMG 1-2	0.431060	Ω
		Ω		PMG 2-3	-	Ω
		Ω		PMG 3-1	-	Ω

STRIP HEATERS		
LOCATION	RESISTANCE	HI-POT
MAIN	19.6 Ω	1 KV
DE BEARING	121 Ω	1 KV
ODE BEARING	115 Ω	1 KV
EXCITER	364	1KV

TESTED BY
CJR
RCD
LEO
JS
-
-

	ACV	ACI	KVA	KW	P.F.	PMV	PMI	EFV	EFI	HZ
(4) OPEN CIRCUIT SATURATION	110							0.0	0.0	50
	0							0.0	0.0	0
	0							0.0	0.0	0
	0							0.0	0.0	0
	5040							15.0	0.8	50
	5670							17.4	0.9	50
	0							0.0	0.0	0
	6300							21.3	1.1	50
	0							0.0	0.0	0
	6930							28.2	1.4	50
	7560							40.7	2.1	50
	8190							67.5	3.4	50
	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-
INHERENT VOLTAGE REGULATION	6300	366	3998	92	0.0	222.1	0.0	57.9	2.9	50
	7997	0	7	0	0.0	222.1	0.0	57.9	2.9	50
(7) VOLTAGE REGULATION	6299	366	3992	90	0.0	220.7	1.1	57.0	2.9	50
	6306	1	7	0	0.0	222.0	0.3	22.1	1.1	50
CCCT	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-
SHORT CIRCUIT CAPABILITY	25	2101				201.3	12.1	194.8	9.8	1490 RPM

(8)

CODE:	4P10.7-3050	
EXC. POLARITY	F1 +	
RES. VOLT	110	
CONN.	Wye	
ROTATION	CWFDE	
SEQUENCE	T1-T2-T3	
BEARINGS	OK	
INSULATED ENDBELL	100	MEG Ω

SHAFT CURRENT	
SS-ma:	-
SS-mv:	-

(9)

MECH. BALANCE	in/sec (RMS)	
	HORZ	VERT
DR. END	0.014	0.012
OPP. END	0.028	0.039
AXIAL	0.013	

AIR GAP (MINIMUM)	
EXCITER	0.042
PMG	0.030

(3)

DIELECTRIC STRENGTH		
	VOLTS	mA
GEN. ARM.	13600	1020
GEN. FLD.	1500	19
EXC. ARM	1500	0
EXC.FLD	1500	0
PMG	1500	3

EMBEDDED TEMPERATURE DETECTOR VERIFICATION						
(10)	TD1	TD2	TD3	TD4	TD5	TD6
	109.0	109.0	109.0	109.0	109.0	109.0
	DTD	OTD	DTD2	OTD2	AIR IN/OUT	
	109.0	109.0	109.0	109.0		
TYPE:	RTD	INSULATION RESISTANCE:			550.0	MEG Ω

(5)

PHASE BALANCE					
	ACV			ACI	
T1 - T2	6300	1-N	3638	L1	366
T2 - T3	6302	2-N	3639	L2	366
T3 - T1	6301	3-N	3638	L3	366

(2)

INSULATION RESISTANCE		
GEN. ARM.	8010	MEG Ω
GEN. FLD.	550	MEG Ω
EXC. ARM.	550	MEG Ω
EXC. FLD.	550	MEG Ω
PMG	550	MEG Ω

PER UNIT SHORT CIRCUIT CURRENT	NUMBER OF LEADS	LEADS CONNECTED WHEN SHIPPED	VOLTAGE REGULATOR MODEL:	VOLTAGE REGULATOR S/N:	VOLTAGE ADJUST RANGE (VAC MIN)	VOLTAGE ADJUST RANGE (VAC MAX)	SCRIBE SHAFT	DISTANCE FROM MECHANICAL CENTER TO ELECT. CENTER (INCHES)
5.74	6	4	DECS 250	ABC123	5659	6935	NO	-

FINAL WIRING CHECKED & VERIFIED TO PRINT BY	DFD CHECKED	UFL SET @ (HZ)	AIR FILTER SET POINT (INCHES OF WC)
OK	NA	49	N/A

SINGLE PHASE PMG	
VOLTS	AMPS
241	0
0	54
222	0

NOTES:

1. Winding resistance
2. Insulation resistance
3. High-potential test
4. O.C. saturation data
5. Phase balance
6. Voltage transient (shown on next page)
7. Voltage regulation
8. Phase sequence
9. Mechanical balance
10. Options (RTDs, space heaters)

Voltage Transient Test Sheets

T.A. 5 (2.7.6)

TEST RECORD

Kato Engineering

Serial Number	12345-01		
Model Number	AAXXXXXXXX		
5200	KW	6500	KVA
6900	Volts	3	Phase
60	Hz	900	RPM
Temperature Rise	105 / 40	°C	
Rotation	CWFDE		

Customer Valued KATO Customer

Test - Voltage Dip and Rise

Date 8/5/2013

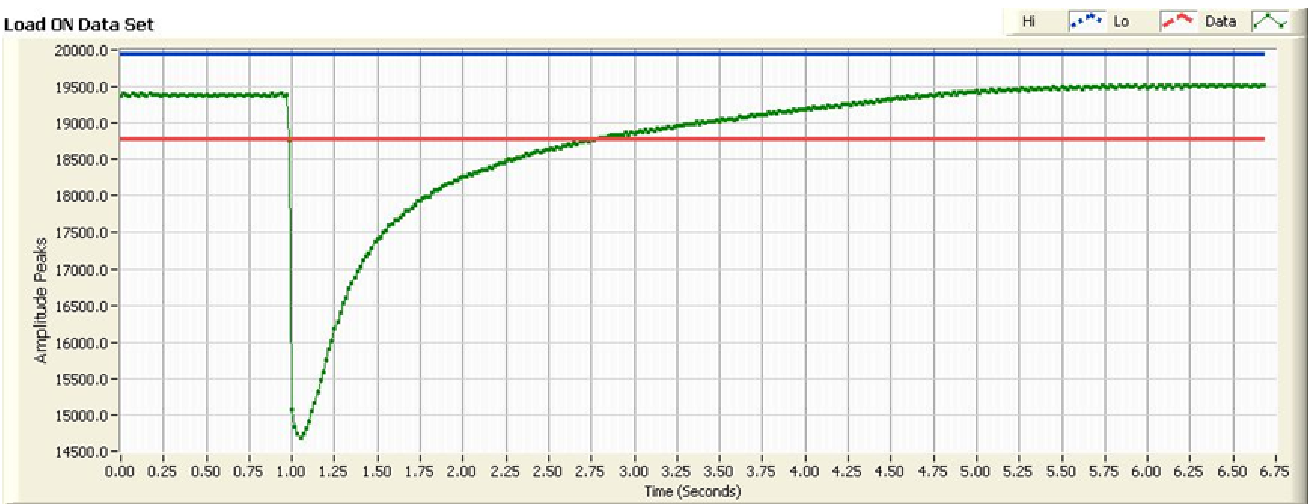
Spec. VT006

Tested By: MJW

Form: VDR Rev. B

Applied Load		**Load ON Results**	
Load Applied (% rated KVA)	100%	Voltage Dip %	24.2
Power Factor	0.0	3.0% Recovery Time (secs)	1.817

Notes



Voltage dip on load application

Voltage Transient Test Sheets (cont.)

TEST RECORD
Kato Engineering

T.A. 5 (2.7.6)

Serial Number	12345-01		
Model Number	AAXXXXXXXX		
5200	KW	6500	KVA
6900	Volts	3	Phase
60	Hz	900	RPM
Temperature Rise	105 / 40	°C	
Rotation	CWFDE		

Customer Valued KATO Customer

Contract Number or P/O

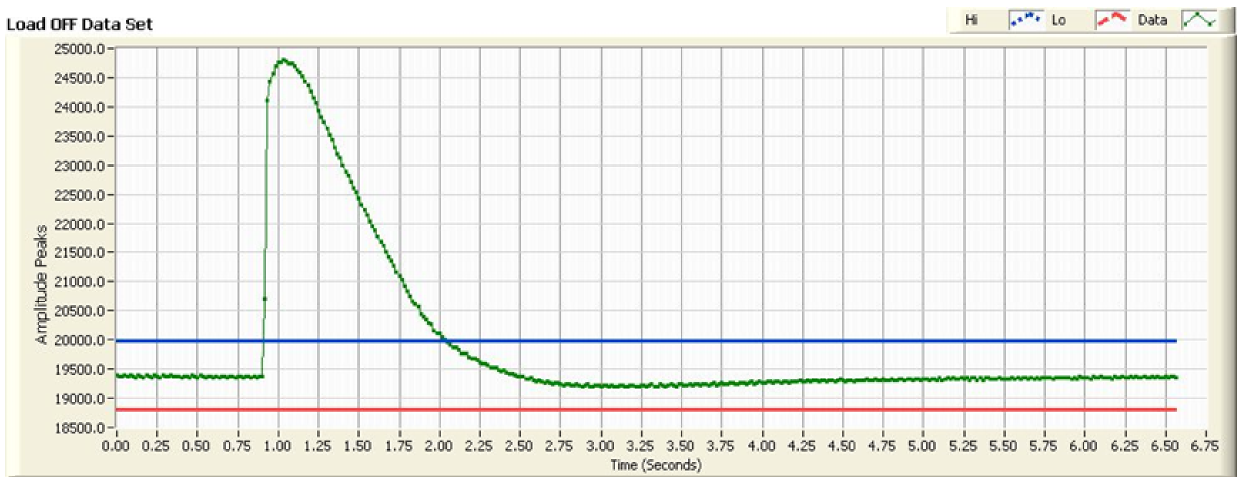
Test - Voltage Dip and Rise

Date	8/5/2013
Spec.	VT006
Tested By:	MJW

Form: VDR Rev. B

Removed Load		Load OFF Results	
Load Removed (% rated KVA)	100%	Voltage Rise %	27.9
		3.0% Recovery Time (secs)	1.133

Notes	



Voltage rise on load removal

Special Tests

- Open-circuit saturation with slip rings
- Synchronous impedance curve (short-circuit saturation)
- Zero power factor saturation curve
- Summation of losses (efficiency test)
- Direct axis synchronous reactance (XD)
- Negative-sequence reactance (X2)
- Zero-sequence reactance (XO)
- Direct-axis transient reactance (X'D)
- Direct-axis sub-transient reactance (X"D)

Special Tests (cont.)

- Direct-axis transient short-circuit time constant (T’D)
- Direct-axis sub-transient short-circuit time constant (T”D)
- Short-circuit time constant of armature windings (TA)
- Direct-axis transient open-circuit time constant (T’DO)

Special Tests (cont.)

- Overspeed
  - Hot or cold (or both)
  - Coastdown after overspeed (another option)
- Voltage waveform (harmonic analysis)
  - THD
  - Deviation Factor
  - TIF
- Bearing temperature rise test - Run until bearing temperatures stabilize, peak bearing temps reported
- Winding temperature-rise test
  - Run until windings have stabilized thermally, rise by resistance calculated
  - Several options: Standard, API, extended run time
  - Vibration monitored and recorded during test

Application Specific Special Tests

- To ensure accurate design, pricing, etc. … Must be communicated at RFQ
- Some tests first unit only
- May require agency witness
- Marine (ABS, DNV-GL, BV)
  - Over speed
  - Overload
  - Transient at 60%
  - Hi-pot and insulation resistance
  - Air gap of exciter and PMG
  - Sustained short circuit
  - Possibly heat run and / or enclosure IP verification

Application Specific Special Tests (cont.)

- Hazardous locations
  - Class-1 Div-2 or Zone 2
  - Heat Run to determine winding temperature rise
  - Test of space heaters (to verify maximum surface temperature)
  - 110% overload for 1 hour
  - Overspeed

Generator Efficiency Test

- Measurement methods: direct vs. indirect (summation of losses) method depends on the manufacturing plant test equipment
- Calculation methods: NEMA vs. IEC (usually higher)
- I^2R reference temp:
  - (observed winding temperature rise + 25° C) or temps based on insulation class (95° C = Class B, 115° C for Class F)
  - At site conditions, site ambient temp + winding temp rise (40° C + 80° C = 120° C)
- Method of guarantee
  - Value may have a 10% tolerance on the stated loss

Voltage Transients

- Can be stated as an amount of voltage dip or rise that occurs for a given load. E.g.,15% dip for 60% load applied.
- Can be specified as an amount of load (skVA) applied or removed with a given dip or rise, respectively. E.g., 2,000 skVA, <20% V dip.
- Can be specified with definition of the exact loads being applied (load characteristics, sequence, and max allowable V dip required).
- What is the starting method? Across-the-line, soft-start…
- How many machines are in parallel?
- Is there any preload on the generator? If so, what type?
- Voltage transient performance data given assumes constant speed.
- Remember to allow adequate room for momentary variation in driver RPM.

Reactances

- Typical tolerance is +/- 15% of stated value for X'd and X"d per IEC60034-3
  - Unless stated otherwise, X'd = 14% means 11.9% < X'd < 16.1%
- Is there an absolute minimum or maximum value defined for a given project?
  - If so, we need to know! If an absolute minimum or maximum is defined, we can design accordingly to meet the requirement.
  - Example: If there is a requirement for a minimum X"d of 15%, we can design for a tolerance of +30% / -0% per IEC to be sure the result is above the minimum.