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

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)**

### Table

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<th>RPM</th>
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### Open-Circuit Saturation

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### Inherent Voltage Regulation

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### Options

- RTDs
- Space heaters
Voltage Transient Test Sheets

Voltage dip on load application
Voltage Transient Test Sheets (cont.)

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 ($X_D$)
- Negative-sequence reactance ($X_2$)
- Zero-sequence reactance ($X_O$)
- 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 + $25^\circ C$) or temps based on insulation class ($95^\circ C = $ Class B, $115^\circ C$ for Class F).
  - At site conditions, site ambient temp + winding temp rise ($40^\circ C + 80^\circ C = 120^\circ C$).
- 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.