# A Comparison of Contemporary Electrical Distribution Equipment Standards

San Francisco IEEE
Industry Applications Society
May 26, 2009

# What are “Standards”?

- Clearly defined performance characteristics
- Based on tested performance under expected worse case parameters
- Generally based on third party certification of tested performance
- Vendor or supplier independent

**Provide the basis for objective based comparison of performance under expected conditions of operation**

# An Example



05/17/04 AP Photo

# Contemporary Standard -- Octane

- RON = Research Octane Number (fuel based); MON = Motor Octane Number (load/timing based)
- PON = Pump Octane Number; PON = (RON + MON)/2
- Uniform among suppliers to allow selection of proper grade by users,

BUT,

- Does not prevent misapplication due to perception
- Does not insure all suppliers offer the same product/features
- Can be revenue/margin tool for vendor

# High Octane – Premium Unleaded

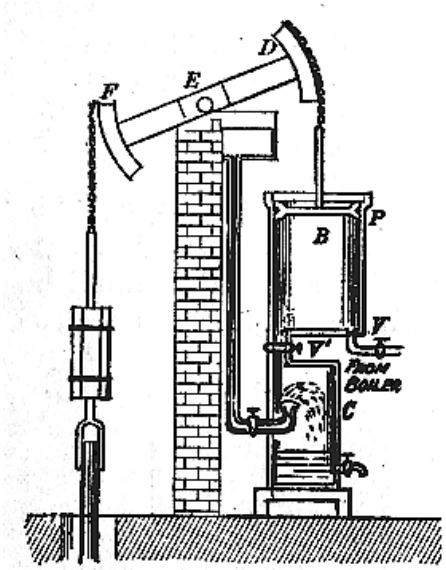
# Low Octane – Regular Unleaded

# What Rating is Required?

# Electrical Distribution Equipment

- Divides Larger Amounts of Power into Smaller "Chunks"
- Can contain control and metering/monitoring devices
- Contains protective feeder devices whose prime role is to protect feeders
- Low Voltage Application include Panelboards, Switchboards, Switchgear

# Watt's Engine




James Watt
1736 -- 1819

$$E = IR$$

$$W = EI$$

**746 Watts = 1 Horsepower**

**600 Amps @ 480V 3ph = 665 HP**

**10,000 Amps @ 120V 1ph = 1600 HP**

# Office Building


**65,000 AIC @ 480V = 72,300 HP**

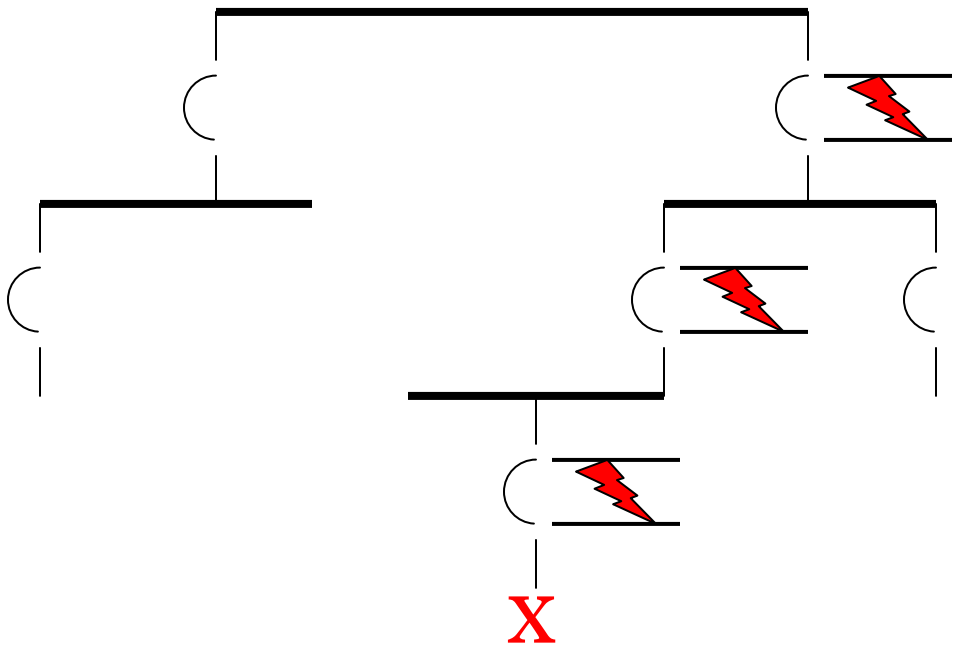
# Medium Voltage

**40,000 AIC @ 13,800V = 1,300,000 HP**

# Fault Testing

# Fault Testing

# Interaction in Equipment

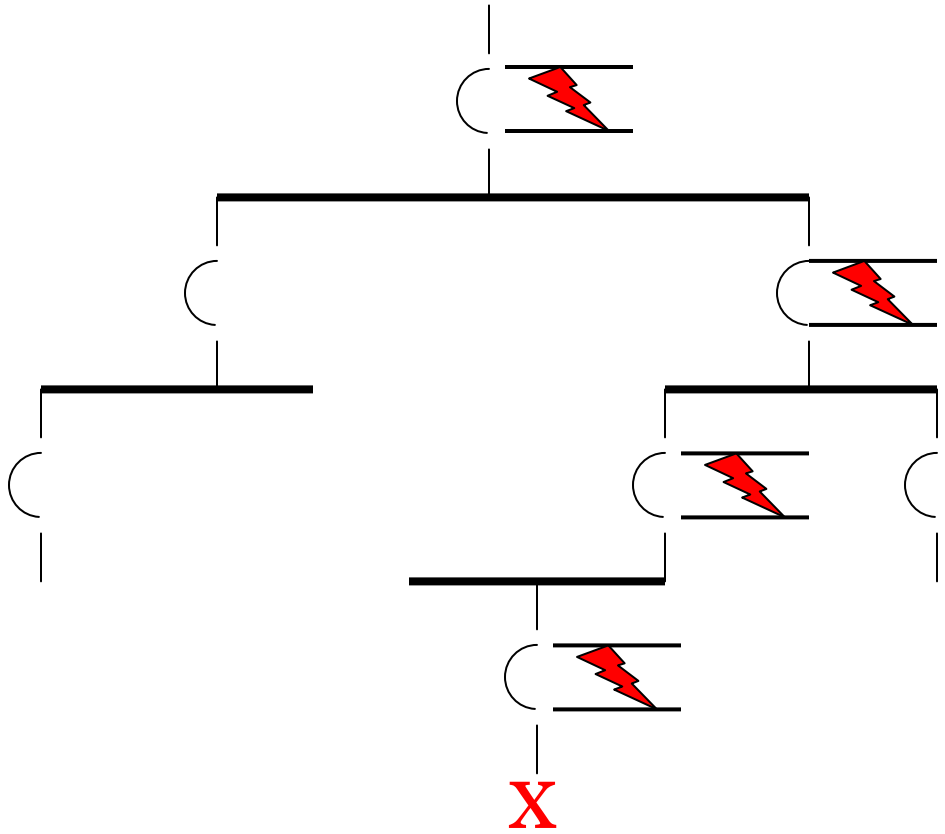



- Opening Contacts Create Arcing
- Arcing Creates Resistance
- Resistance Reduces Current Flow
- Reduced Current Flow Can Affect Opening Speed
- Reduced Opening Speed Will Affect Energy Flow

# Dynamic Interactions

- Individual devices react to what they see
  - Circuit Breakers react to over current or short circuit conditions
  - Relays operate based on on conditions sensed
- Individual devices react to the reaction of other devices
  - A circuit breaker that is tripping (opening under load) will affect the current and voltage seen by other devices

# Selectivity Can Be Impacted




- Depending on fault level, more than one device can open on a downstream fault
- Loads without faults can be affected or interrupted
- Entire systems can be shutdown by downstream faults
- May be part of design for series ratings

# Possible Conditions of Operation

- High Energy Levels – Need to insure proper operation at possible fault levels
- Dynamic Interaction – Need to understand possible device interactions under fault conditions
- Selectivity – Need to insure required selectivity under all potential fault conditions

BUT,

- Cost – Need to meet all performance requirements within budgetary constraints

# LV Equipment Standards

- NEMA –Switchboards PB-2/Switchgear SG-5
  - No longer writing standards; still responsible for certain breaker testing standards
- ANSI – Switchgear C37.20
  - Publishes standards; no longer creates standards for electrical equipment
- IEEE – Switchgear C 37.20
  - Develops standards for equipment/breakers
- UL – Switchboards UL 891/Switchgear UL 1558
  - Both develops standards and serves as third party certifier of devices and systems

# Switchboards or Switchgear

- Terms often used interchangeably by many in industry; Switchgear is generic term
- Per NEC Article 100, difference is far from contemporary.
- Objective differences now defined by UL/ANSI standards for equipment

BUT,

- Many design elements can overlap
- Common components possible

# Devices, not Equipment are Key

- OCPD (Over Current Protective Devices) determine the operational characteristics of the equipment
- Application of OCPDs determines equipment type (equipment standards)
- As in most cases, compromises may be required to obtain optimal solution for particular situation

# Circuit Breakers

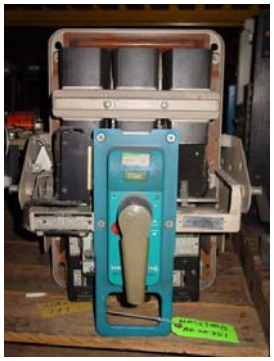
## LV Power Circuit Breakers

- Since 1985, LV Power Circuit Breakers listed under UL 1066
- Formerly under ANSI C37.13 and C37.50 (not UL)
- Classic design was iron frame; most now enclosed with non-metallic materials
- Allow for maintenance of internal parts for long service life
- Higher performance and higher cost

## Molded Case Circuit Breakers

- Listed under UL 489
- Includes “insulated” case circuit breakers
- Classic design was toggle type thermosetting or thermoplastic sealed case
- Sealed case prevents normal maintenance
- Tend to be lower cost than Power Circuit Breakers
- High AIC ratings possible

# LV Power Breakers Evolution



1999?

2007

?

1999

2001

2002

2005

# Key Differences UL 489 vs. UL 1066

- Higher endurance testing for UL 1066 at all ratings (e.g., 800A – 500 cycles UL 489; 800 cycles UL 1066 at FLA)
- Short time withstand test required for UL 1066 rating – maintain high level current for 0.5 seconds
- Single pole testing for UL 1066
- Different power factor requirements for testing
- Different heat rise requirements for testing

# Switchboards or Switchgear -- UL

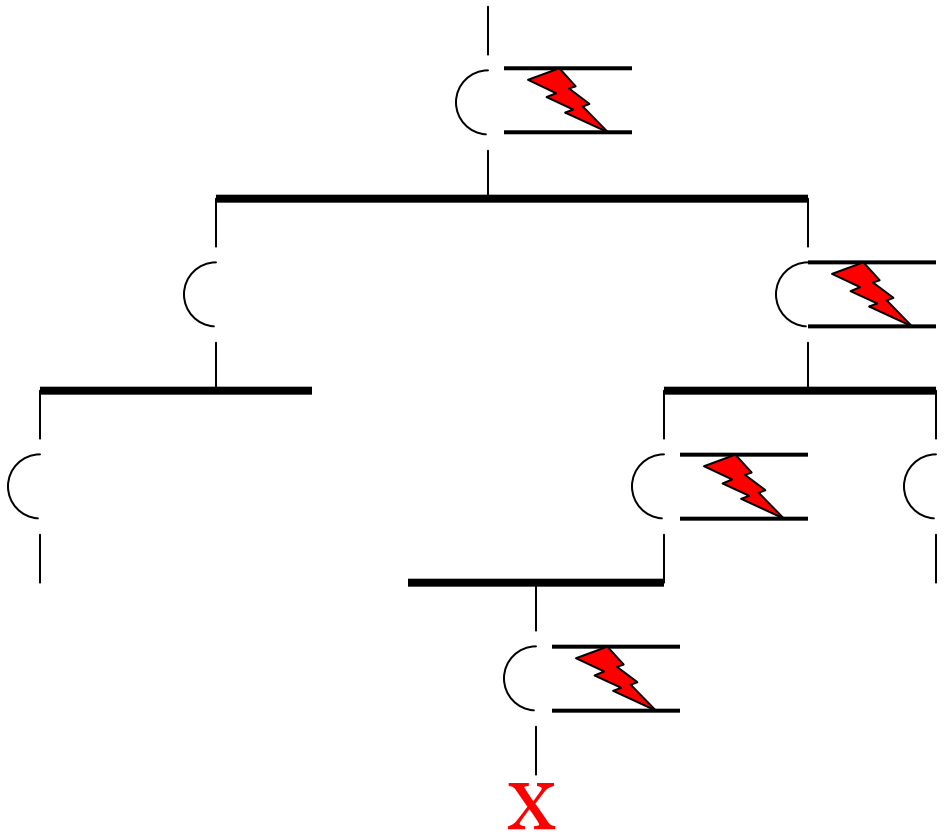
- Switchgear listed to UL 1558 since 1982
- Based on ANSI C37 standards
- Uses UL 1066 listed breakers
- Generally requires rear access for load and incoming connections
- “Compartmentalized” Construction with breaker compartment for each device
- Tested to short circuit rating for 4 cycles (.067 seconds)
- Tested to short time rating for 30 cycles (0.5 seconds)
- Heat Rise tested Bussing

- Switchboards listed to UL 891
- Uses UL 891 or UL 1066 listed breakers
- Can be front connected without rear access requirements
- Devices can be individually (vertically) or group (panel/horizontally) mounted
- Tested to short circuit rating of 3 cycles (.05 seconds) or to instantaneous trip of tested OCPD or braced to UL configuration standards
- Heat Rise Tested or Density Rated

# Why Require UL1558/UL1066?

- Allows use of tested assemblies/devices without instantaneous trips for selectivity
  - May be required to allow for slower relays for differential protection
  - Will insure selectivity to limit of short time ratings (to instantaneous over ride limits)
- May provide features/designs not available in UL 891 products from some manufacturers
  - Insulated and/or isolated bussing
  - Protected wire ways for LV controls

# Selectivity Can Be Restored




- By eliminating instantaneous on one or more levels, selectivity can be maintained
- Arc Flash protection can be enhanced by differential relaying or arc flash relays
- Requires UL 1558 equipment for LV applications wherever instantaneous protections is eliminated

# Why Not?

- Unless features/characteristics are not available in UL 891, UL 1558 equipment tends to be more costly.
  - GE study showed 1.6 to 2.0 unit cost difference between equivalent UL 891 and UL 1558 assemblies
- Rear access may not be available
  - Foot prints may be similar in square footage; required space may vary due to rear clearance requirements
- UL 1066 devices can be used in UL 891 equipment
  - Some manufacturers offer equivalent UL 489 devices; others only offer UL 1066 devices
  - Can NOT “turn off” instantaneous trip and maintain UL
- Unusual busing configurations may not be available in UL 1558 equipment
  - Only tested configurations are possible in UL 1558; UL 891 can use approved bracing configurations to create “custom” configurations.

# Diesel – The European Standard

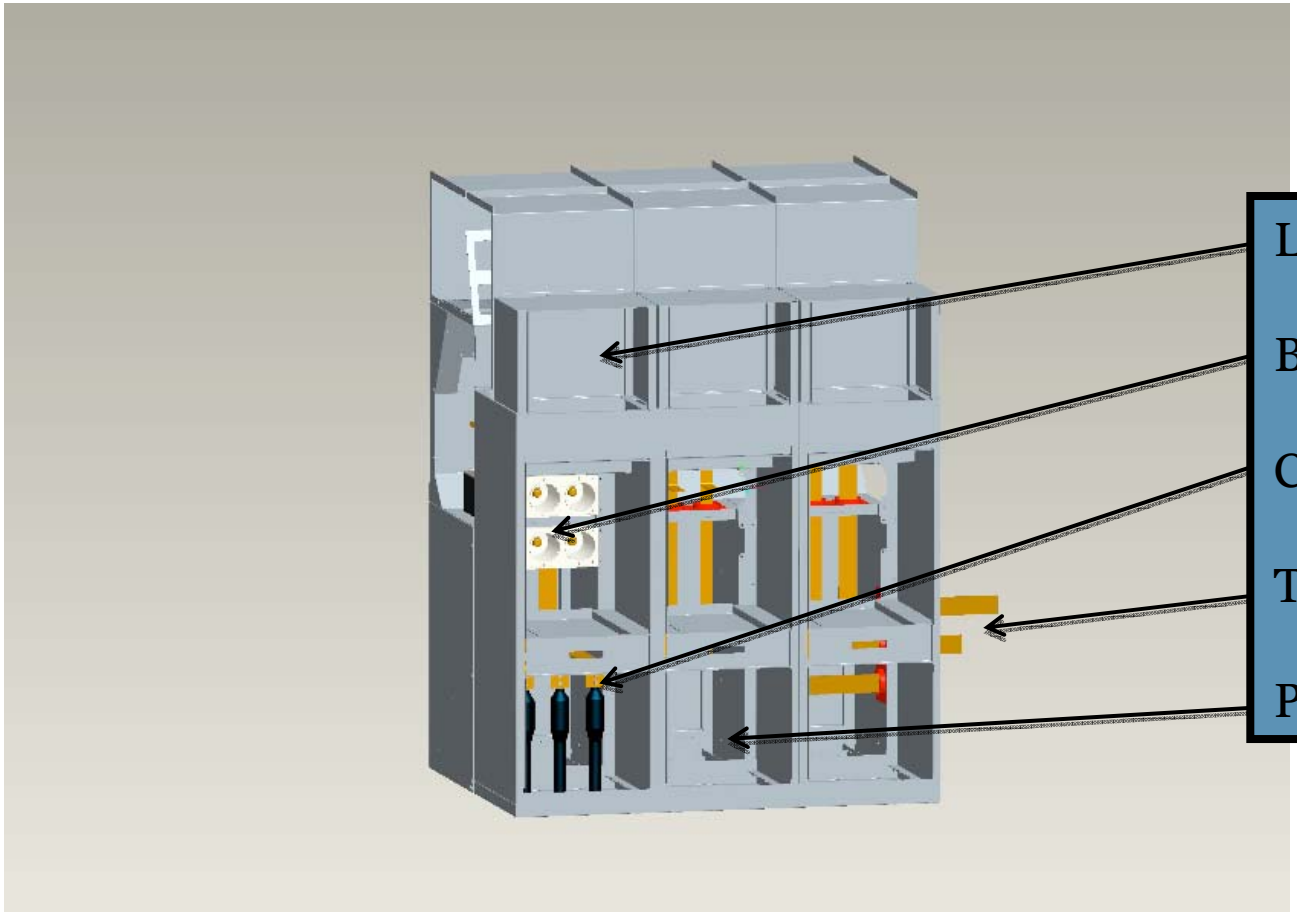
# Standards Vary

# IEC Standards

- IEC 60439 -1 (Low Voltage Switchgear and Controlgear Assemblies)
  - Can be either TTA (Type Tested Assembly) or PTTA (Partially Type Tested Assembly)
  - PTTA requires calculations for those parts not type tested
  - Includes both Switchgear and Switchboard equivalents
- IEC 60947 (Low Voltage Power Circuit Breakers)
- IEC 298 (Medium Voltage Switchgear and Controlgear Assemblies
  - Includes both metal enclosed and metal clad equivalents

# Significant Configuration Differences

# Typical MV Configuration



# IEC Adaptations

- Many components originally designed for IEC markets successfully adapted/modified to meet UL standards
- IEC electrical equipment products generally not yet adapted to UL standards although efforts are ongoing
- IEC MV equipment successfully adapted to CSA standards (required some IEEE/ANSI testing)
- Increased demand for IEC equipment by users
- Often supplied as part of other equipment for food processing or similar applications

# Final Notes

- Knowledge of standards and implications will drive most cost effective solutions for varied applications – one size does NOT fit all
- Differentiating between what is required by standards and what is desired for the particular application (particularly on features) will allow more choices as to suppliers
- Final acceptance of equipment is dependent on local authorities (AHJ). Independent certification of standards will usually insure acceptance.