Substations - Volume VII: Other Major Equipment

An Online Continuing Education Course for Engineers

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Preface

This course is one of a series of thirteen courses on the design of electrical substations. The courses do not necessarily have to be taken in order and, for the most part, are stand-alone courses. The following is a brief description of each course.

Volume I, Design Parameters. Covers the general design considerations, documents and drawings related to designing a substation.

Volume II, Physical Layout. Covers the layout considerations, bus configurations, and electrical clearances.

Volume III, Conductors and Bus Design. Covers bare conductors, rigid and strain bus design.

Volume IV, Power Transformers. Covers the application and relevant specifications related to power transformers and mobile transformers.

Volume V, Circuit Interrupting Devices. Covers the specifications and application of power circuit breakers, metal-clad switchgear and electronic reclosers.

Volume VI, Voltage Regulators and Capacitors. Covers the general operation and specification of voltage regulators and capacitors.

Volume VII, Other Major Equipment. Covers switch, arrestor, and instrument transformer specification and application.

Volume VIII, Site and Foundation Design. Covers general issues related to site design, foundation design and control house design.

Volume IX, Substation Structures. Covers the design of bus support structures and connectors.

Volume X, Grounding. Covers the design of the ground grid for safety and proper operation.

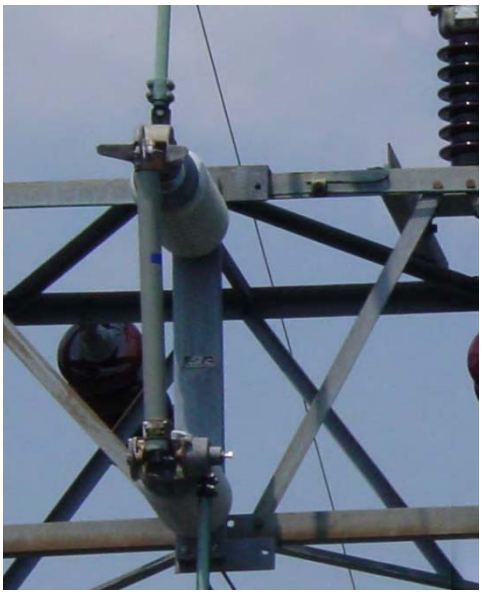
Volume XI, Protective Relaying. Covers relay types, schemes, and instrumentation.

Volume XII, Auxiliary Systems. Covers AC & DC systems, automation, and communications.

Volume XIII, Insulated Cable and Raceways. Covers the specifications and application of electrical cable.

Chapter 1: Air Switches

This chapter deals with high-voltage air switches used in substations. Items discussed include applicable national standards, types of air switches, various constructions of outdoor air switches, service conditions, ratings, and tests.



An *air switch* is defined as a switching device designed to close and open one or more electrical circuits by means of guided separable contacts that separate in air. Air, at atmospheric pressure, is also the insulating medium between contacts in the open position.

All varieties of air switches used in a substation need to generally conform to all applicable national standards and guides. The principal standards and guides for air switches are the following:

- ANSI Std. C29.1, "Test Methods for Electrical Power Insulators"
- ANSI Std. C29.8, "Wet-Process Porcelain Insulators (Apparatus, Cap and Pin Type)"
- ANSI Std. C29.9, "Wet-Process Porcelain Insulators (Apparatus, Post Type)"
- ANSI Std. C29.10, "Wet-Process Porcelain Insulators (Indoor Apparatus Type)"
- ANSI Std. C37.32, "Standard for Switchgear—High-Voltage Air Switches, Bus Supports, and Switch Accessories—Schedules of Preferred Ratings, Manufacturing Specifications and Application Guide"
- ANSI/IEEE Std. C37.100, "IEEE Standard Definitions for Power Switchgear"
- IEEE Std. C37.34, "Test Code for High-Voltage Air Switches"
- IEEE Std. C37.35, "Guide for the Application, Installation, Operation and Maintenance of High-Voltage Air Disconnecting and Load-Interrupter Switches"
- NEMA Std. SG-6, "Power Switching Equipment"

Types of Air Switches

The main types of air switches are determined by and named according to their application. And there are standard definitions describe their general functions.

Disconnecting or Isolating Switch

A *disconnecting* or isolating switch is a mechanical switching device used for changing the connections in a circuit, or for isolating a circuit or equipment from the source of power. This switch is required to carry normal load current continuously and, also, abnormal or short-circuit currents for short intervals as specified. It is also required to open or close circuits either when negligible current is broken or made, or when no significant change in the voltage across the terminals of each of the switch poles occurs. Typical Applications include,

1. Circuit breaker isolation
2. Power transformer isolation
3. Voltage transformer disconnecting
4. Equipment bypassing
5. Bus sectionalizing

Where the current to be broken or made is not negligible, a horn-gap switch should be used.

Grounding Switch

A *grounding switch* is a mechanical switching device by means of which a circuit or piece of apparatus may be electrically connected to ground. Grounding switches are often mounted on the jaw or hinge end of disconnecting or horn-gap switches. Typical Applications include,

1. To ground buses or circuits (for safe maintenance) after they are first isolated
2. To intentionally ground a circuit (using an automatic high-speed device) in order to activate a remote protective relaying scheme

Horn-Gap Switch:

A *horn-gap switch* is a switch provided with arcing horns. To de-energize or energize a circuit that possesses some limited amount of magnetic or capacitive energy, such as transformer exciting current or line charging current. The arcing horns protect the main contacts during opening or closing and enhance the ability of the switch to perform its task. Where the amount of current to be broken or made is not clearly within the switch's capability, consult the manufacturer or use an interrupter switch.

Interrupter Switch:

An *interrupter switch* is an air switch, equipped with an interrupter, for making or breaking specified currents, or both. The nature of the current made or broken, or both, may be indicated by suitable prefix, that is, load interrupter switch, fault interrupter switch, capacitor current interrupter switch, etc. Typical applications are indicated by the above-named prefixes.

Selector Switch

A *selector switch* is a device arranged to permit connecting a conductor to any one of a number of other conductors. In substation applications, it is unlikely that more than two conductors would be subject to selection. Typical Applications include,

1. To connect a potential device to either of two buses
2. To perform a joint disconnecting and grounding function

Various Constructions of Outdoor Air Switches

Outdoor air switches are constructed in many different styles or construction classifications. Preferred standard ratings are listed in Tables 1, 2, and 3.

Table 1
Typical Voltage Ratings
Station Class Outdoor Air Switches

Rated Maximum Voltage (kV, RMS)	Rated Withstand Voltage			Corona and Radio Influences Test Voltages	
	Lightning Impulse (kV Peak)	Power Frequency (kV, RMS)		Test Voltage (kV, RMS)	Limit of RIV (mV @ 1 MHz)
		Dry 1 Minute	Wet 10 Seconds		
8.25	95			-	-
15.5				-	-
25.8	1			-	-
38.0	2			-	-
48.3	25			-	-
72.5	25 35			-	-
121	350 450 550			77 77 7	500 500 500
145	350 450 550 650			2 92	500 500 500 500
169	450 550 650 750	 280 335 385	190 230 270 310	107 107 107 107	500 500 500 500
242	550 650 750 900 1050	280 335 385 465 545	230 275 315 385 455	154 154 154 154 154	500 500 500 500 500
362	1050 1300	545 610	455 525	230 230	500 500
550	1550 1800	710 810	620 710	349 349	500 500