

# STANDARDS, APPLICATIONS AND TESTING OF MEDIUM VOLTAGE BUS DUCT

By Peter Wicks

There are basically three general categories of bus duct (all-metal enclosed). The non-segregated phase bus implies a duct where all phase conductors are in a common metal enclosure without barriers between phases. This definition applies to rigid and flexible conductors such as the bar or cable duct.

Segregated phase bus is a duct where phase conductors are in a common metal enclosure but are segregated by ground metal barriers between each phase conductor.

Isolated phase duct is when each phase conductor is enclosed in its own metal housing and adjacent conductor housings are separated by an air space. This duct usually has higher amp ratings

than other types. The housing and conductors are tubular in shape and are welded at site together. This duct is force-air cooled above a 25000A continuous rating.

## APPLICABLE STANDARDS

ANSI C37.23 standard covers the design, manufacture, testing and ratings of the all-metal enclosed bus duct, including cable duct systems. When part of the equipment, it contains the associated equipment such as inter connections, enclosures, switches, supporting structures and disconnecting links. This includes disconnects primarily used with isolated phase duct but can be used with all other types of duct, including cable duct.

Outside the scope of this standard is duct rated to 600V or open type conductor assemblies.

The CSA C22.2 No. 201 standard is the Canadian measure for metal-enclosed duct for voltages rated from 751V to 46kV, AC or DC. This standard covers the design, manufacture, testing and rat-





the duct system's physical arrangement. The installing contractor welds the conductors and housing in the field.

Isolated phase ducts are used for high ampacity requirements and can be supplied up to 25000A continuous rating without forced-air cooling. Beyond this rating, forced-air cooling is required with all the associated equipment. All accessories such as elbows, tees, the isolating switch and termination to the equipment it feeds are specifically designed for the application and generally come factory assembled, except for termination. Isolated phase duct is quite special compared to the other duct systems described and requires considerably more space. It is also significantly more expensive to purchase and install, but deemed a unique system for specific applications and, in particular, as a generator duct feed.

In general, rigid conductor type bus duct length is measured from centre line to centre line, and the equipment to which it is attached, to establish overall duct-length footage. Bar extensions within a termination cubicle are considered part of the termination equipment. For cable duct, the same criteria is used to establish length. The only exception is that 60 inches of duct length must be added to establish overall length dimensions, due to the cable extension leads required at each end. Such cable lead extensions are considered part of the duct length, rather than part of the termination equipment.

#### RATINGS

Non-segregated duct, which includes cable duct, basically has the same continuous current ratings, from 600A to 6000A. Duct of higher ratings is supplied up to 12000A, but this is for special applications requiring special design, manufacturing and installation considerations. Ampacities are normally based on 40°C ambient where conductors have silver-plated joints, and the allowable temperature rise of the conductor is 65°C. Non-current carrying parts that can be readily touched are allowed a 40°C rise.

Ambient temperature range limits are -30°C to +40°C, and altitude is up to 1000 metres (3300 feet). Other ambient conditions need special consideration and may contribute to de-rating. Voltage range for these types of duct are basically from above 600V to 34.5kV to ANSI but to 46kV to CSA. In practical terms, the maximum rating is 38kV with a BIL rating of 150kV. This includes cable duct, even though cable at nominally 38kV can have a higher BIL rating and can certainly have a higher insulating voltage class such as up to 33 per cent insulation on higher voltage ratings. To ANSI standards, corona extinction levels are not specified, but they are to CSA standards and are considered a production type test.

Momentary ratings are not specified in the standards but the duct is expected to be suitable and match the momentary

rating of the equipment to which it is connected.

In general terms, the momentary ratings offered are 82 kA, 100kA or 150kA for 600V ratings; 60kA, 80kA and 100kA for five and 15kV ratings; 6kA and 80kA for 25 and 38kV ratings. The DC bus duct nominal voltage rating is 300 to 3200 volt DC with continuous ratings up to 6000A. Isolated phase duct continuous ratings go from 1200 to 24000A (self-cooled) although tests have been conducted to 25000A for self-cooled current ratings.

Voltage ratings are 24.5, 29.5 and 34.5kV with corresponding BIL ratings of 110, 125 and 150kV for direct generator connections. Other than generator connection, voltage levels are 15.5, 25.8 and 38kV with corresponding BIL ratings of 110, 125, and 150kV.

#### GENERAL FEATURES AND APPLICATION NON-SEGREGATED PHASE BUS DUCT

Non-segregated phase bus duct is available for voltages ranging from 600 volts through 38kV, with ratings up to 8000 amps. The duct has all phase conductors in a common enclosure with air space between phases. There are no metallic barriers between phase conductors of adjacent points. Conductors may be mounted on custom-molded, fiberglass-reinforced polyester blocks or on post insulators. Enclosures that are totally enclosed are preferred, but ventilated areas can be provided in indoor applications. Typical applications include connections between motor transformers and switchgear, tie connections between motor control centres and large motors, and as the main generator lead for small generators.

#### SEGREGATED PHASE BUS

Segregated phase bus duct is available for voltages ranging from 600 volts through 38kV, with ratings up to 8000 amps. Segregated phase bus has all phase conductors in a common enclosure with metal barriers between adjacent phases. Conductors may be mounted on molded, fiberglass-polyester blocks or on post insulators. This design is primarily used as a generator lead in power plants, but it is also used in heavy industrial applications and as a switchgear tie in metal-enclosed substations.

#### BUS WITH PORCELAIN SUPPORT INSULATORS

For voltages higher than 15kV and currents above 5000 amps, porcelain post insulators are the preferred means of support for the phase conductors. However these post supports may be used as the main conductor support at any lower voltage or current. Applications are similar to those listed for non-segregated phase and segregated phase bus duct.

#### CABLE BUS

Cable bus consists of a metal enclosure containing conductors that are fully insulated copper cables. Using support blocks, the cables are maintained at spacings slightly greater than two cable diameters between centres to achieve maximum operating current for each cable. Cable bus can be supplied at voltages up to 38kV and currents up to 5000 amps. Applications include connections between transformers and switchgear, ties between switchgear and switchgear, and connections between motor control centres and large motors.

#### DC BUS

The DC Bus voltage ranges from 300 to 3200V DC with amp ratings of 600 to 6000A. It can be supplied to meet the



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needs of most direct current applications. DC bus is available in two basic configurations: with both poles contained in the same enclosure, or with each pole contained in a separate enclosure. If the termination areas for opposite poles are located side by side, then the common enclosure configuration is used. When a considerable distance exists between poles at the termination, or when the continuous current or short-circuit rating is high, separate enclosures may be used. Applications include generator exciter systems, power feeds for electric furnaces and various connections in traction power installations.

### APPROVALS

Rigid conductor bus duct systems are not U/L approved or certified, as there are no standards in existence. CSA approval and labelling can be applied to rigid conductor bus duct systems. Such approval is undertaken at the plant of manufacture and applied to an individual project, as blanket approval is not obtainable. Special inspection authorization is available in Canada in the field, in lieu of CSA approval in the plant. This is often more economical and certainly less time consuming than in plant certification and labeling. Cable duct approval has to be obtained in the field once the cable is installed and terminated, as it is only partially manufactured in the plant. Approval is not available as with rigid conductor duct systems. Special in-field inspection is the only way to get approval and this again can be CSA or special inspection, the latter being the preferred way.

The approach for the isolating phase duct is very much the same as cable duct since it requires field certification and labelling.

### PROS AND CONS FOR THE USE AND APPLICATION OF EACH TYPE OF DUCT SYSTEM

For non-segregated, segregated and cable duct, the equipment price determines the application and which type to use. In general, the cable duct is less expensive (equipment wise). Based on actual cost examples evaluated over the years, a cable duct system costs less overall than a rigid conductor type duct system for standard installations. A rigid conductor duct type system requires strip heaters in the outdoor application to prevent condensation forming on the insulated conductors. Cable duct does not, as standard insulated cable is used, which is identical for indoor or outdoor application.

Rigid duct is normally totally enclosed, and cable duct is ventilated. Rigid duct requires periodic checks to the bar joints to endure continued tightness of bolts along its entire length. Cable duct only requires such checks at termination points, as the cable is a continuous conductor along its length.

Rigid duct insulation levels are determined by the insulation level applied to the bar and is fixed by standards. For example, cable duct can readily be increased by using cable with a 133 per cent insulation level.

Rigid duct requires accurate fixed dimensions in the field and the duct has to be manufactured to the exact dimensions and these must be maintained in the field to levels of plus or minus 1/4 inch. With cable duct, it is much more site forgiving in dimensions as the cable is field installed. After the duct housing is installed, the duct housing is more readily adjustable (length wise) than rigid duct, which includes the conductor installed in the factory.



### DESIGN AND PRODUCTION TESTS

Design tests for rigid conductor type bus duct include dielectric tests; temperature rise tests for the housing and the conductor to establish continuous current rating; momentary current test to establish bar bracing; basic impulse test; and corona extinction tests to meet Canadian standards.

Production tests include dielectric tests and corona extinction tests to comply with Canadian standards.

Design tests can be performed as production tests, but this is not recommended due to cost and the length of time it takes to do these tests.

Design tests for cable duct include dielectric test of the cable only; temperature rise tests of the cable only (although design tests and calculations are originally conducted to establish housing size and suitable ventilation); momentary current tests on cable only (although calculations have been conducted to establish the cable support system within the duct and their spacings); basic impulse tests on cable only; and corona extinction levels on cable only.

Production tests for cable duct generally only include a cable dielectric test at the manufacturer's plant.

Design tests are not available as a production test from the cable manufacturer, although duct system calculations can be provided at an added cost.

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