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REVISIONS: UPDATED LEGAL ACKNOWLEDGEMENT FORM. FD MAR '16

|                                                                                                                  |                                                                                                                  |                                                                                                              |                                                                                                           |                                                                                                      |  |                |
|------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|--|----------------|
| DESIGNED<br><br>J. AGNOLIN                                                                                       | RECOMMENDED<br><br>F. DENNERT | ACCEPTED<br><br>G. REIMER | ENGINEER OF RECORD<br> | NOTICE FROM THE<br>EXECUTIVE VICE PRESIDENT<br>TRANSMISSION AND DISTRIBUTION<br>AND CUSTOMER SERVICE |  |                |
| DISTRIBUTION<br>STANDARDS<br> |                                                                                                                  | ISSUED: MAR 2016<br>REPLACES: MAY 2004<br>ORIGINALLY<br>ISSUED: NOV 1980                                     |                                                                                                           |                                                                                                      |  | PAGE 1<br>OF 2 |

## Scope

This manual is one of a series containing standards for construction of the BC Hydro electrical distribution plant within the service area of BC Hydro. A new distribution plant shall be designed, constructed, owned, operated, maintained and repaired to these standards.

## Purpose of Standards

BC Hydro objectives require standardization to:

- Ensure uniform safety requirements comply with BC statutes and regulations.
- Provide uniform system reliability.
- Provide uniform operating practices.
- Permit economic bulk purchasing of materials.
- Achieve optimum life cycle cost of plant construction.
- Effect efficient quality assurance.

## Responsibility

The Distribution Standards Department prepares these standards and verifies that specified plant and procedures will perform adequately under all normally expected conditions encountered throughout the province of British Columbia. These standards are approved by Professional Engineers. It is the responsibility of BC Hydro Managers to ensure that the standards are followed unless abnormal conditions are encountered that require variations. These variations should be kept to a minimum and their performance shall be the responsibility of the Professional of Record in charge of the project, who will record and seal the variation based on satisfactory qualifications and experience to do so. As per the latest revision of the BC Hydro Distribution Owner's Engineer Guide, these variations must be accepted by BC Hydro's Owner's Engineer.

## Use of Stock Materials

The electrical distribution plant covered by these standards is built using stock materials approved by a Professional Engineer as required by law. The use of non-stock materials for special and unusual situations must be approved by Distribution Standards or the BC Hydro Engineer responsible for the project.

## Revisions to Manual

These standards are revised from time to time to improve the safety, performance, workability, cost effectiveness or appearance of the plant. The existing plant built to previous standards need not be updated unless so specifically advised by BC Hydro. When maintenance or other work, such as voltage conversion or conductor change is being done, updating plant to current standards is encouraged.

## Mailing Addresses

The manual has been issued to a corporation or firm rather than to an individual. The corporation or firm is responsible for the safekeeping of the manual, and for keeping it current. Changes of address or in number of copies required must be reported promptly.

Suggestions for changes in the manual, or required changes of address may be made on the pre-addressed comment sheet included in the Manual and with each issue of revision.

REVISIONS: UPDATED LEGAL ACKNOWLEDGEMENT FORM. FD MAR '16

|                                       |                                                                                                                  |                                                                                                              |                                                                                                                                                                         |                                                                                                      |                           |        |
|---------------------------------------|------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|---------------------------|--------|
| DESIGNED<br>J. AGNOLIN                | RECOMMENDED<br><br>F. DENNERT | ACCEPTED<br><br>S. REIMER | ENGINEER OF RECORD<br><br>F. U. DENNERT<br>PROFESSIONAL ENGINEER<br>BRITISH COLUMBIA | NOTICE FROM THE<br>EXECUTIVE VICE PRESIDENT<br>TRANSMISSION AND DISTRIBUTION<br>AND CUSTOMER SERVICE |                           |        |
| DISTRIBUTION<br>STANDARDS<br>BC Hydro |                                                                                                                  | ISSUED: MAR 2016<br>REPLACES: MAY 2004<br>ORIGINALLY<br>ISSUED: NOV 1980                                     |                                                                                                                                                                         | PAGE 2<br>OF 2                                                                                       | ES43/53/54/55/65 A1-01.02 | R<br>4 |



## Information Bulletin: Backfill

### Revision Note

Revised text since R0 edition is shown with a vertical bar in the margin, changed or added text is underlined, and deleted text is crossed-out.

### 1.0 Items Covered

Class of Work Specification 1322 R9.1

Construction of Underground Electrical Distribution Structures by a BC Hydro Contractor

Class of Work Specification 1323 R8.2

Construction of Underground Electrical Distribution Structures by a Customer

### 2.0 Overview

The backfill materials in the above Class of Work Specifications were updated to align with the Authorities Having Jurisdiction requirements for backfill. Materials surrounding direct buried ducts and concrete duct banks were changed from sand to granular material to prevent migration of the material away from the area surrounding the ducts and duct bank due to high water tables.

The backfill materials for traffic areas aligns with materials from the Master Municipal Specifications from the Master Municipal Construction Documents Association and the Ministry of Transportation and Infrastructure.

In boulevard areas, the Class of Work Specifications allow selected native material for backfilling the trench based on consideration that such areas may have limited access and hauling an imported material may not be feasible. However, it is expected that the selected native material meets the Class of Work Specification compaction and gradations specified for Bedding material, and BC Hydro reserves the right to review and reject the proposed native material if not appropriate.

### 3.0 Action

Effective August ~~10~~20, 2015, projects must use the appropriate fill materials as per the Class of Work Specifications. Note that the ES54 civil standards, which are presently under revision and will be issued in fall of 2015, will contain further alternatives to the materials specified in the Class of Work specifications and are included in the appendix as a reference. These materials

are also acceptable and provide greater flexibility than those specified in the Class of Work Specifications.

## 4.0 Figures

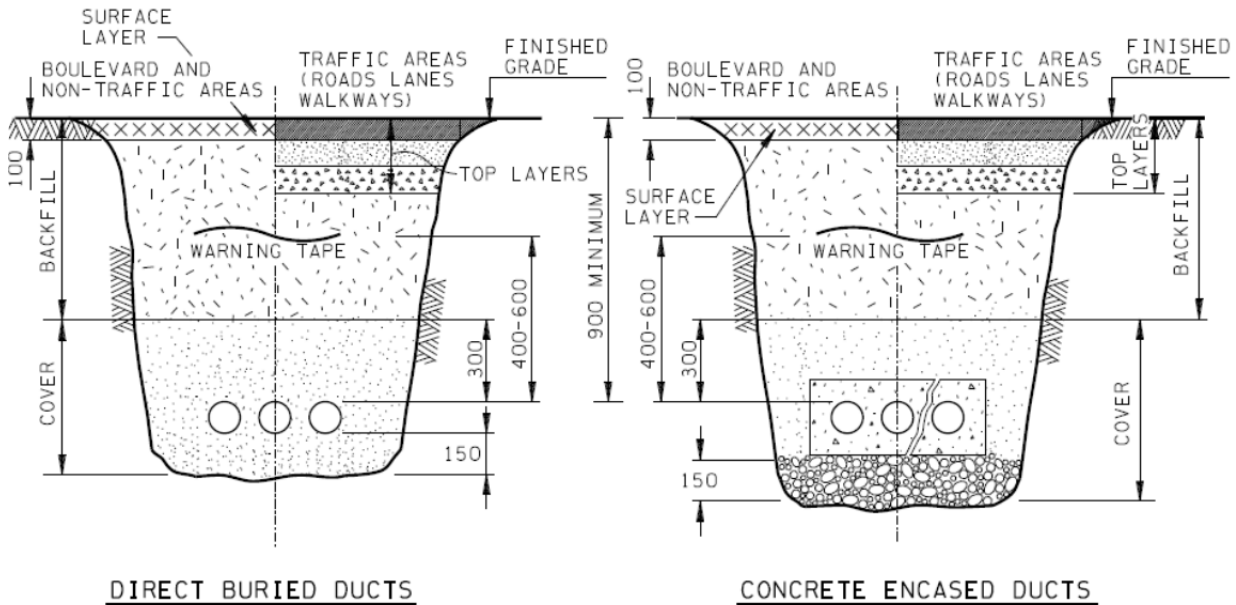


Figure 1: Trench Cross Sections

|                    | Boulevard and Non-Traffic Areas                                                                                                                                                                                                                                                 | Traffic Areas<br>(Roadways, access lanes, sidewalks)                                                                                                                                                       |
|--------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Backfill Materials | <p>Surface layer is aligned to Authority Having Jurisdiction where applicable and</p> <p>Material below the surface layer is Bedding Material</p> <p>or</p> <p>Selected native fill subject to the note below</p> <p>Compaction must be 85% <u>Modified</u> Procter density</p> | <p>Top layers are aligned to Authority Having Jurisdiction where applicable and</p> <p>Material below the top layers is Bedding material</p> <p>Compaction must be 95% <u>Modified</u> Procter density</p> |
| Cover Materials    | <p>Pit run placed 150mm under direct buried ducts, and to extend around ducts and 300mm above highest duct</p> <p>Approved aggregate, pit run or bedding material placed 150mm under concrete encased duct bank, and to extend 300mm above highest duct</p>                     |                                                                                                                                                                                                            |

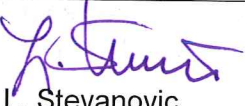
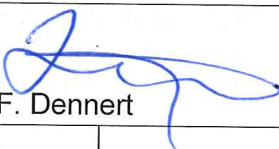
**Note:** Selected Native Material shall be approved excavated material, free from frozen lumps, ashes, refuse, vegetable organic or foreign matter, granular material over 100 mm in any dimension, or other deleterious materials, and shall be accepted by BC Hydro. Native material is not acceptable if it is impracticable to control its water or compact to the specified density. Contractor to provide test results of gradation, compaction, and thermal resistivity if applicable, to BC Hydro's representative for acceptance.

Table 1: Acceptable Materials

## 5.0 Distribution Standards Contact

|                           |                                                                                             |
|---------------------------|---------------------------------------------------------------------------------------------|
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| Phone #: 778.452.6779     | Cell #: 604.209.5661                                                                        |

## 6.0 Approval

| Recommended   |            | Reviewed                                                                                           |            | Approved                                                                                         |            |
|---------------|------------|----------------------------------------------------------------------------------------------------|------------|--------------------------------------------------------------------------------------------------|------------|
| L. Stevanovic |            | <br>L. Stevanovic |            | <br>F. Dennert |            |
| Date:         | 2015-04-20 | Date:                                                                                              | 2015-04-20 | Date:                                                                                            | 2015-04-20 |

## Appendix

Further clarification is provided with the upcoming revisions to the ES54 Underground Civil Standards, section W. These DRAFT materials are included here for clarification on acceptable materials, testing and compaction.

### Fill Materials

Fill material shall be selected native or material imported from a source acceptable to BC Hydro's Representative. Fill placed around and above feeder duct banks (typically 5 inch ducts) shall not exceed a maximum thermal resistivity of 0.9 mm x C / W at 2% moisture content, and at constructed compaction Proctor Density.

#### Cover

Cover is an approved fill material placed at the bottom of the excavation to the elevation 300 mm above direct buried ducts and duct banks, and around vaults and boxes. Cover placed around direct buried duct banks shall be Pit Run material. Cover placed around concrete encased duct banks shall be any of the Aggregate materials, except for Coarse Drain Rock, which can be placed at the base below the concrete structure only.

#### Backfill

Backfill is an approved fill material placed below the finished grade or top layers to the bottom of excavations for concrete encased cut banks, and to the top of the Cover for direct buried ducts. Backfill material shall be Aggregate except Course Drain Rock, Selected Native Material or Consolidated Density Fill. Coarse Drain Rock may be used as a base for concrete encased duct banks.

#### Aggregate

Aggregate shall compose of inert, clean, tough, durable, highly angular, 100 percent mechanically crushed fragments, with two or more fractured faces having a rough surface texture and capable of withstanding the deleterious effects of exposure to water, freeze-thaw, handling, spreading and compacting. It shall be uniform in quality, and free from an excess of flat or elongated particles, wood, shells, coatings of clay or any other deleterious material.

Aggregate gradation shall be determined in accordance with the ASTM C 136 (Dry Sieve Test) and, for the material passing the 0.075 mm sieve, ASTM C 117 (Wash Sieve Test). Gradations shall fall within the limits for the specified classification, as shown in the following table.

| Aggregate Gradation     |                               |                      |                      |              |         |                   |
|-------------------------|-------------------------------|----------------------|----------------------|--------------|---------|-------------------|
| Sieve Opening Size (mm) | Present Passing by Weight (%) |                      |                      |              |         |                   |
|                         | MOTI OGB                      | Granular Base Type 1 | Granular Base Type 2 | Pipe Bedding | Pit Run | Coarse Drain Rock |
| 25.0                    | 100                           | -                    | 100                  | 100          | -       | 100               |
| 19.0                    | 75-100                        | 100                  | 80-100               | 90-100       | -       | 0-100             |
| 12.5                    | -                             | 75-100               | 50-85                | 65-85        | 100     | -                 |
| 9.50                    | 30-65                         | 60-90                | 35-70                | 50-75        | -       | 0-5               |
| 4.75                    | 5-30                          | 40-70                | 25-50                | 25-50        | 35-100  | -                 |
| 2.36                    | 0-10                          | 27-55                | 15-35                | 10-35        | 20-70   | -                 |
| 1.18                    | -                             | 16-42                | 5-20                 | 6-26         | 13-50   | -                 |
| 0.600                   | -                             | 8-30                 | -                    | 3-17         | 8-35    | -                 |
| 0.300                   | 0-8                           | 5-20                 | -                    | -            | 5-25    | -                 |
| 0.150                   | -                             | -                    | 0-5                  | -            | 2-15    | -                 |
| 0.075                   | 0-5                           | 2-8                  | -                    | 0-5          | 0-6     | -                 |

**Notes:**

- 1) MOTI OGB, Granular Base Type 1, Type 2 and Pipe Bedding are high strength and quality crushed aggregate.
- 2) Pit Run is clean graded or crushed aggregate.
- 3) Course Drain Rock is highly permeable, clean, round graded or crushed aggregate.

**Aggregate Acceptance**

| Test Description        | Test Methodology                             | Minimum Test Frequency                                            | Acceptance Criteria                                           |
|-------------------------|----------------------------------------------|-------------------------------------------------------------------|---------------------------------------------------------------|
| Sieve Analysis          | ASTM C136 and ASTM C117 for 0.075 mm sieve   | One (1) per 1,000 cubic metres for each type of backfill material | Generally uniform gradations within the limits shown in Table |
| Sand Equivalent         | ASTM D2419                                   | Same as above                                                     | Equal to or more than 40                                      |
| Laboratory Compaction   | ASTM D1557                                   | Same as above                                                     | Meets the gradation requirements                              |
| Micro Deval Loss Factor | ASTM D6928                                   | Same as above                                                     | Equal to or less than 25%                                     |
| Soundness               | ASTM C88                                     | Same as above                                                     | Loss after 5 cycles is less than 20% (25% for 4.75 mm)        |
| Rut Resistance          | Rolled with a fully loaded tandem axle truck | Same as above                                                     | Shall not rut                                                 |

### Selected Native Material

Selected native material is the material which has been removed from an excavation and accepted by the BC Hydro Representative for return to the same excavation as fill material. Such material shall be separated from unsuitable excavated material.

Selected native material shall be granular material free from frozen lumps, ashes, refuse, vegetable, organic or foreign matter, granular material over 100 mm in any dimension, or other deleterious materials. Native material is not acceptable if it is impracticable to control its water content, or to compact to the specified density.

### Controlled Density Fill

Controlled Density Fill (CDF) shall be designed by the EOR and accepted by BC Hydro's Representative. CDF mix design shall be the sole responsibility of the Contractor. All materials and methods of control density fill shall conform to CAN/CSA-A23.1 and CAN/CSA-A23-2.

### Lightweight Fills

Lightweight Fills include, but are not limited to, Expanded Polystyrene (EPS, also known as Extruded Polystyrene, STYROFOAM™, GeoFoam™, etc.); pumice; cellular lightweight concrete (e.g. Cell-Crete™); lightweight expanded clay aggregate, and wood waste (hog fuel). Lightweight fills restrict heat dissipation and are not permitted to be placed in the area adjacent to and above the duct banks.

### Fill Construction

Fill materials shall be placed uniformly and compacted, in lifts not exceeding 200 mm loose thickness. Frozen material shall not be used as fill material, and fill material shall not be placed on frozen ground, and it shall be compacted in dry conditions.

Fill shall extend a minimum 150 mm below the base of the structure and duct bank. All irregularities and cavities in the base shall be properly backfilled, compacted and levelled at a tolerance no greater than  $\pm 10$  mm. The Contractor shall not proceed with further Work until the bottom of the excavation and the prepared base have been inspected and accepted by BC Hydro's Representative. Any soft areas or inappropriate materials, in the opinion of BC Hydro's Representative, encountered at the bottom of the excavation shall be excavated and replaced with appropriate material.

### Cover and Backfill Construction Acceptance

| Location                                                                                                                                                                                     | Modified Proctor Corrected Compacted Dry Density (%) |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|
| Non-traffic area (where the distance from the excavation to the roadway, sidewalk, curbs, walls or structures is greater than the excavated depth, otherwise section (b) below shall govern) | 85 %                                                 |
| (b) All other areas:                                                                                                                                                                         |                                                      |
| Depths within 1.2 metres of the finished surface                                                                                                                                             | 95 %                                                 |
| Depths below 1.2 metres from the finished surface                                                                                                                                            | 95 %                                                 |