S-1 (2105/2106) EXCAVATION AND EMBANKMENT (3D PRODUCTION MONITORING SYSTEM FOR MUCK EXCAVATION)

Always use this provision when using SP2015-xxx.x (2013 Survey Equipment – 3D Production Monitoring System (3D-PMS) for Muck Excavation).

REVISED 04/21/15  DO NOT REMOVE THIS. IT NEEDS TO STAY IN FOR THE CONTRACTORS.

SP2015-xxx.x

The following is added to 2105.3J / 2106.3J:

S-1.1  2105.3J.2 / 2106.3J.2 Hold Point

Failure to resolve the 3D-PMS Failure by the beginning of the next day of operation constitutes a Hold Point, whereby no additional material may be placed, and/or removed until the 3D-PMS Failure has been resolved and meets the requirements of S-xx.2.A of SP2015.xxx.xx “(2013) Survey Equipment – 3D Production Monitoring System (3D-PMS) for Muck Excavation”.

Replace 2105.2.A.4 / 2106.2.A.4 with the following:

S-1.2  2105.2.A.4 / 2106.2.A.4 Materials: Muck Excavation

The removal of organic soils as defined in 2105.1A.10, “Organic Soils,” and other unstable soils as designated by the Contract.

The following is added to 2105.4.A / 2106.4A:

S-1.3  2105.4.A / 2106.4A Method of Measurement: Excavation Material

In addition to these requirements, the Department will calculate these quantities by using the 3D surface model for the bottom of Muck Excavations submitted by the Contractor as required by 2013.601 “Survey Equipment – 3D Production Monitoring System (3D-PMS) for Muck Excavation”. Failure to submit an acceptable model and meet the requirements of 2013.601 “Survey Equipment – 3D Production Monitoring System (3D-PMS) for Muck Excavation” will subject this work to MnDOT 1512, “Unacceptable or Unauthorized Work.”

3D-PMS data, for creation of the 3D surface model for the bottom of the muck excavation, must be exported from the 3D Web-Based Production Monitoring software, using the project extent dates for the limits of each excavation area. All exports for volume calculations must start on the first day of excavation for the given area to the current date to ensure that the lowest elevation is captured in the exported data. Volume calculations, for a given time period, will use the running accumulative total volume less that for the previous period(s).

The following is added to 2105.4.B / 2106.4B:

S-1.4  Method of Measurement: 2105.4.B Borrow Material / 2106.4B Embankment Material

In addition to these requirements, the Department will calculate these quantities by using the 3D surface model for the bottom of Muck Excavations submitted by the Contractor as required by 2013.601 “Survey Equipment – 3D Production Monitoring System (3D-PMS) for Muck Excavation”. Failure to submit an acceptable model and meet the requirements of 2013.601 “Survey Equipment – 3D Production Monitoring System (3D-PMS) for Muck Excavation” will subject this work to MnDOT 1512, “Unacceptable or Unauthorized Work.”

3D-PMS data, for creation of the 3D surface model for the bottom of the muck excavation, must be exported from the 3D Web-Based Production Monitoring software, using the project extent dates for
**the limits of each excavation area.** All exports for volume calculations must start on the first day of excavation for the given area to the current date to ensure that the lowest elevation is captured in the exported data. Volume calculations, for a given time period, will use the running accumulative total less that for the previous period(s).

The following is added to 2105.4 / 2106.4:

S-1.5 2105.4.E / 2106.4.E Method of Measurement: Muck Excavation

All excavated materials below in-place roadway surfacing, concrete or bituminous, or topsoil in areas designated as muck excavation shall be paid for as muck excavation, exclusive of rock or rock channel excavation.

Replace Table 2105-7 / 2106-7 with the following in 2105 / 2106:

S-1.6 Table 2105-7 / 2106-7

<table>
<thead>
<tr>
<th>Depth below topographic surface prior to project commencement</th>
<th>Compensation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 ft. – 15 ft. [0 m – 5 m]</td>
<td>Muck Excavation Contract Unit Price</td>
</tr>
<tr>
<td>&gt; 15 ft. – 20 ft. [&gt; 5 m – 7 m]</td>
<td>Muck Excavation Contract Unit Price plus $0.30 per cubic yard [$0.39 per cubic meter]</td>
</tr>
<tr>
<td>&gt; 20 ft – 25 ft. [&gt; 7 m – 9 m]</td>
<td>Muck Excavation Contract Unit Price plus $0.50 per cubic yard [$0.65 per cubic meter]</td>
</tr>
<tr>
<td>&gt; 25 ft. [&gt; 9 m]</td>
<td>Negotiated Price</td>
</tr>
</tbody>
</table>

NOTE: These price adjustments are payment in full for all additional costs incurred. Exception: Compensation for additional Muck Excavation may be subject to the provisions of 1402, “Contract Revisions”.

**S-2**  **(2013) SURVEY EQUIPMENT – 3D PRODUCTION MONITORING SYSTEM (3D-PMS) FOR MUCK EXCAVATION**

Always use this provision when using SP2015-xxx.x (2105/2106 Excavation and Embankment (3D Production Monitoring System for Muck Excavation).

REvised 04/21/15  **DO NOT REMOVE THIS. IT NEEDS TO STAY IN FOR THE CONTRACTORS.**

SP2015-xxx.x

S-2.1 **Description**

Use a 3D Production Monitoring System for collection and recording of GNSS coordinates for creation of a 3D model reflecting the Muck Excavation bottom.

The Advanced Materials and Technology Manual and all 3D-PMS forms are available on the MnDOT Advanced Materials and Technology Website:

http://www.dot.state.mn.us/materials/advancedmaterialsandtechnology.html

**(A) DEFINITIONS**

Refer to the MnDOT Advanced Materials and Technology Manual for definitions not included below:

(1) *Muck Excavation*—see 2105.2/2106.2.A.4.
3D Production Monitoring System (3D-PMS)—is a grade control system attached to excavation equipment that uses either a 3D GNSS or Universal Total Station System to document and record excavation depths. The system is integrated with an onboard documentation system that displays a real-time color-coded maps of the excavation depths, current excavator location, depth above or below design and more.

3D Production Monitoring System (3D-PMS) Failure—is when the 3D-PMS does not collect and/or store data per the requirements of S-xx.2.A, and or the excavator becomes inoperable.

(B) Acronyms and Abbreviations

1. D—dimensional
2. GNSS—global navigation satellite system
3. GPS—global positioning system
4. RTK—real time kinematic
5. RTRN—Real Time Reference Network
6. 3D-PMS—3D production monitoring system
7. UTC—Coordinated Universal Time

S-2.2 EQUIPMENT REQUIREMENTS

(A) 3D Production Monitoring System (3D-PMS)

1. Attach the 3D-PMS to the Equipment to be used for Muck Excavation.

2. The 3D-PMS must be instrumented with the following:
   
   a) Capability to use the County Coordinate System File and a Geoid Model (both to be provided by the Department) for site calibration.

   b) Modem, or Wi-Fi, for transferring data to Cloud Storage.

   c) Onboard Documentation System.

   At a minimum, the Onboard Documentation System must:

   c1) Collect and store GNSS coordinate data.

   c2) Have the ability to manually export data using a removable media device.

   c3) Display real-time color-coded maps of:

       i) Linework (Alignment Files)

       ii) Excavator Location

       iii) Elevation

   c4) Display Current Value for:
(i) GNSS Coordinates,
(ii) Current Elevation and
(iii) Design Elevation

(d) Submersible enclosures for sensors may be needed, if the equipment is anticipated to be submerged into water.

(3) 3D-PMS Data

(a) The GNSS Coordinates must:

(a1) have an accuracy of ± 0.2 ft (5 cm) in the horizontal and vertical directions (X, Y and Z Direction);

(a2) be collected, unless otherwise specified, in the County Coordinate System used in the background, alignment file(s) using NAD83 (adjustment as specified by the Department) and NAVD88 vertical datum.

(a3) indicate the cutting edge of the excavation equipment.

(b) The data collection interval during production monitoring must be continuous.

(4) 3D Web-Based Production Monitoring must meet the following requirements:

(a) The data mesh size, after post-processing must be less than or equal to 24 in (600 mm) in the X, Y and Z directions.

(b) Ability to map the following views:

(b1) **Excavation/Fill Elevations:**

(i) Current Elevation
(ii) Lowest Elevation
(iii) Highest Elevation
(iv) First Pass
(v) Last Pass

(b2) **Coverage**—Locations where the 3D-PMS has recorded data.

(b3) **Cut / Fill Map**—Color map of cut and fill (production data) compared to selected designs.

(b4) **Summary Volumes**—Volumes computed between selected surface design files and (a) measured production data at different times; and (b) lowest recorded elevation.

(b5) **Profile Views**—views which include design and recorded production data.

(c) Ability to filter by a minimum of the following:

(c1) Elevation Range

(c2) Date
(c3) Location

(c4) Excavation/Fill Elevations listed in S-xx.2.A.4.b1.

(d) Import and export 3D Models in LandXML format.

(e) Import background (corridor) designs and 3D design surfaces that include station-based alignment data.

(f) Compile data, to create a composite data set and view, if more than one of the excavators is instrumented with 3D-PMS.

(g) Support triangulated 3D surface models.

(h) Import and combine 3D-PMS data with survey data.

(i) Export volume and cut/fill elevation reports in *xls, *csv, and/or *dbase format.

(5) Provide the Department with one (1) user ID for access to the Cloud Storage and Cloud Computing (Web-Based Production Monitoring Software) at the start of excavation efforts until ninety (90) days after final acceptance of all work per MnDOT 1516.2.

Provide the Department with training on viewing, filtering and exporting reports and 3D surface models from Cloud Storage / Cloud Computing.

(B) Rover

(1) The Contractor will use a survey grade GNSS Rover Receiver and Receiver Kit (Rover) for use during the 3D-PMS demonstration and daily GNSS checks.

(2) The Rover must be capable of using the Department provided County Coordinate System File and Geoid Model for site calibration. Additionally, it must display and store the Date, Time and XYZ Coordinates as required by Table S-xx.1. The XYZ Coordinates must be collected, unless otherwise specified, in the County Coordinate System used in the background, alignment file(s) using NAD83 (adjustment as specified by the Department) and NAVD88 vertical datum.

<table>
<thead>
<tr>
<th>Description</th>
<th>Data Format Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date Stamp (MDDYY)</td>
<td>3/19/13</td>
</tr>
<tr>
<td>Time Stamp (HHMMSS,SS –military format)</td>
<td>21:46:22.96 (21 hr 46min. 22.96 s.)</td>
</tr>
<tr>
<td>Northing (Y)</td>
<td>153328.47</td>
</tr>
<tr>
<td>Easting (X)</td>
<td>524195.65</td>
</tr>
<tr>
<td>Height (Z)</td>
<td>909.85</td>
</tr>
</tbody>
</table>

S-2.3 CONSTRUCTION REQUIREMENT

(A) Design Files

(1) The Department will provide the background, alignment file(s) (in DGN, DWG or DXF format), within three (3) working days of Contract approval:
(2) The Department will provide the 3D Topographic Surface Model (in Land XML format) to be used, with the 3D-PMS bottom of Muck Excavation surface model, when calculating volumes.

(3) It is the Contractor’s responsibility to convert the provided Department design files for the selected 3D Production Monitoring System.

(3) The Department is allowed three (3) working days to update files with Department approved changes requested by the Contractor.

(B) Control Points for Site Calibration

(1) The Department will set temporary Control Points, prior to the Project start date, meeting the following requirements:

Note – Permanent Control Points (meeting the following requirements) can also be used, however, the Department must collect coordinates for these points to ensure that there have been no disturbances.

(a) At least one Control Point at each project extent limits sufficient to envelop the location(s) using 3D Production Monitoring.

(c) All Control Points must have a clear line of site to satellites to allow for calibration of the site.

(d) All of the Control Points must be three Dimensional (3D) with an accuracy of \( \leq 0.05 \) ft (15 mm) in the vertical and horizontal direction (X, Y and Z Direction).

(2) The Department will provide the following GNSS coordinate information in a *txt or *csv format, for the permanent and temporary Control Points, 7 working-days prior to the start of Muck Excavation efforts:

(a) Point Name

(b) Northing

(c) Easting

(d) Elevation

(e) Location Code / Description

The Department will also include available MnDOT Geodetic Data Sheets that are relevant to the Project limits.

(C) Site Analysis, Setup and Calibration

(1) Complete site setup and calibration at least seven (7) working days prior to the use of the 3D Production Monitoring System.

(2) Provide the Department with date that the site was setup and calibrated and the location(s) of local, ground-base stations when used.

(3) Use the County Coordinate System File and Geoid Model for the site calibration.

(D) Department Approval of 3D Production Monitoring System for Use
(1) Provide the proposed demonstration location and proposed demonstration date for approval of the 3D-PMS to the Department at least 7-working days in advance to demonstration. The Department will approve the demonstration locations at least 3-working days prior to the 3D-PMS demonstration.

(2) The Department will approve the 3D-PMS(s) for use using Form 3D-PMS-101.

(3) 3D-PMS Demonstration
   
   (a) The demonstration location must be within the limits of the site-calibration.

   (b) Demonstrate that the system meets the requirements of S-xx.2.A and the following:

       (b1) GNSS data is captured with movement of the excavation equipment (current elevation, lowest elevation, highest elevation, first pass, last pass).

       (b2) The data can transfer directly from the 3D-PMS to the Cloud storage.

       (b3) Survey data can be uploaded into the 3D Web-Based Production Monitoring Software.

       (b4) The Department is able to view and access the data within the 3D Web-Based Production Monitoring Software.

       (b5) The 3D surface of the demonstration data can be exported in LandXML format.

(4) Calibration of GNSS Accuracy

   (a) Rover—Verify that the Rover(s) are calibrated to the correct coordinate system, using a Control Point, within the Project limits. Complete this verification prior to checking the 3D-PMS.

   (b) 3D-PMS

       (b1) Complete the verification of the 3D-PMS GNSS measurements at a minimum of 10 locations, at least 2 ft (600 mm) apart.

       (b2) Mark a spot on the natural ground next to the location on the cutting edge of the excavation bucket that is being recorded and displayed by the Onboard Documentation System (e.g., left or right edge of the bucket).

       Note – In general, most systems do not start recording values until the excavation equipment is moving (e.g., the bucket is being pulled towards the operators). Consequently, do not mark the verification locations in advance, but after the excavation bucket is placed at a given location.

       (b3) Collect and compare the GNSS coordinates from the Rover and the 3D-PMS. The coordinates must compare within 0.33 ft (100 mm) of each other in the X, Y and Z direction.
(b4) Record measurements on form 3D-PMS-101.

(E) 3D Production Monitoring

(1) Use 3D Production Monitoring during production efforts at all Muck Excavation locations.

(2) Turn data collection and recording off when not performing Muck Excavation.

(3) Excavate to design depths, unless otherwise specified by the Department.

(4) Notify the Department when cellular coverage is limited or not available.

(5) The Department will conduct independent GNSS checks of the 3D-PMS, at the discretion of the Department, using the procedure outlined in S-xx.3.D.4.b2-b3.

The Department will record measurements on form 3D-PMS-102 and will notify the Contractor if any individual check differs by more than 0.33 ft (100 mm) of that measured using the 3D-PMS.

(6) 3D-PMS Failure

(a) Contact the Department immediately when 3D-PMS Failure occurs (see S-xx.1.A.3) and immediately after the issues have been resolved.

Failure to resolve the 3D-PMS Failure by the beginning of the next day of operation constitutes a Hold Point per S-xx.1 of SP2015-xxx.xx “(2105/2106) Excavation and Embankment (3D Production Monitoring System for Muck Excavation)”.

(b) Use conventional survey methods under the direct supervision of a Licensed Land Surveyor, or using a plan approved by the Department, for the remainder of the working day where 3D-PMS Failure occurs.

(F) Submittal Requirements

Embankment quantities are subject to MnDOT 1512, “Unacceptable or Unauthorized Work”, when the following is not performed:

(1) Submit initial site calibration files within 7 calendar days of completion.

(2) Submit data collected during Department approval of 3D-PMS for use (form 3D-PMS-101, 3D surface file of demonstration data in LandXML format) during the demonstration process.

(3) Store the 3D Production Monitoring data internally at least every 5 minutes and during Muck Excavation transfer the data directly from the 3D-PMS to the Cloud Storage within 15-minute intervals, or at least once per day when there is limited cellular coverage.

S-2.4 METHOD OF MEASUREMENT

Measure the 3D Production Monitoring System(s) as a system(s) furnished, installed and operational on the Contractor’s equipment. The Contractor is responsible to demonstrate that the system will perform satisfactorily in accordance with the provisions of the Contract, regardless of the duration of its use at any one time or location.
S-2.5 BASIS OF PAYMENT

Interruptions in the availability of satellite signals to operate this system will not result in any adjustment to the “Basis of Payment” for any construction items or to Contract time.

The Department will pay for the 3D Production Monitoring System(s) on the basis of the following schedule:

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Item</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013.601</td>
<td>Survey Equipment</td>
<td>Lump Sum</td>
</tr>
</tbody>
</table>