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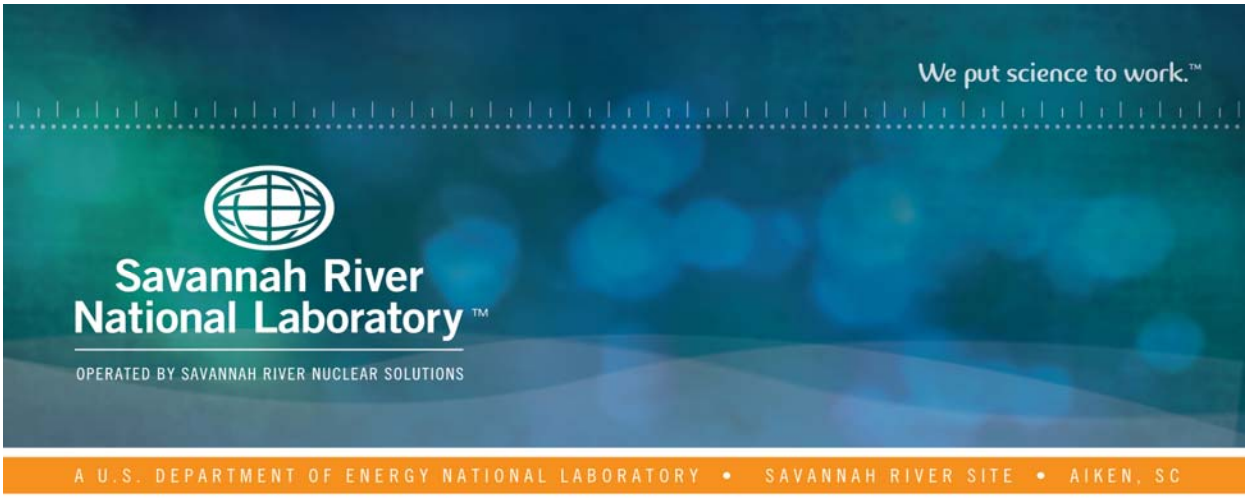

Payload Production for the Fire Testing of Primary Containment Vessels

H. W. Eldridge

J. H. Scogin

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Savannah River National Laboratory™
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PREFACE OR ACKNOWLEDGEMENTS

Savannah River National Lab would like to thank Savannah River Site for their continued support and Sandia National Lab for their collaboration in the fire testing.

EXECUTIVE SUMMARY

One safety concern for the storage of nuclear or hazardous materials within the Department of Energy (DOE) complex is the pressure response behaviors of Primary Containment Vessels (PCVs) of a 9975 shipping package. Although there are many conservative estimates for the pressure response behavior of PCV in high temperature environments, these estimations remain unchecked by experiment. Conservative estimates frequently build in large safety margins which result in a reduced operating range and potentially unnecessary operation restrictions. In an attempt to alleviate some of these barriers, Nuclear & Criticality Safety Engineering (N&CSE) has requested the fire testing of primary containment vessels.

In order to perform meaningful testing, the PCV should contain a realistic payload. As typical payloads of the PCV are composed of nuclear and hazardous materials, SRNL-SASP was requested to design, develop, and produce safe, inert payloads to be used in the fire testing.

Criteria were developed to determine the non-hazardous materials to be used in testing while still accurately representing a typical nuclear payload. Aluminum Oxide (alumina) was selected to represent typical oxides found in payloads due to alumina's inert behavior. Powdered alumina is available in a variety of particle size distributions, providing a means to closely match important characteristics of typical oxides in a PCV payload. Alumina is also available in solid shapes, such as spheres, making it the ideal material to represent solid structures and materials commonly used in PCV packaging. Various plastics are present as packaging materials in PCVs. Polyethylene was used to represent all plastics in a PCV by scaling to the amount gasses produced via pyrolysis.

Once the materials were procured, they were characterized through a variety of analytical methods to ensure the payload's true contents were known. The characterization of the materials was also used in the development of statistical tolerances. These statistical tolerances were developed to guarantee that each payload met the test conditions set forth by N&CSE.

R&D Directions were developed to construct payloads in the optimal configuration for payload shipment, storage, and use in fire testing. Once the design and directions were approved by all parties involved, the final payloads were constructed and shipped to SNL for fire testing.

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LIST OF ABBREVIATIONS

SRNL	Savannah River National Laboratory
N&CSE	Nuclear & Criticality Safety Engineering
PCV	Primary Containment Vessels
ARF/RF	Airborne Release Fraction/Respirable Fraction
SRNL-SASP	Savannah River National Lab-Separation and Actinide Science Program
TO-577	Task Order 000577-001
3188	M-CLC-H-03188
AD	Analytical Development
XRD	X-Ray Diffraction
XRF	X-Ray Fluorescence
PSD	Particle Size Distribution
TGA-MS	Thermogravimetric Analysis-Mass Spectrometry

1.0 Introduction

Many DOE facilities have nuclear or hazardous materials stored in containers do not have experimentally determined pressure response behaviors in the event of a fire. Lack of test data related to fire exposure requires conservative safety analysis assumptions for container response, creating large safety margins which in turn may result in a reduced operating range and potentially unnecessary controls. N&CSE has requested the fire testing of primary containment vessels (PCV) that are used throughout the DOE complex.

The purpose of these tests is to obtain the fire response behavior for pressurized releases that include identification of failure specific characteristics such as: pressure and temperature failure points, leak/burst failure type, and conservative estimates of the Airborne Release Fraction/Respirable Fraction (ARF/RF) associated with solid radioactive materials stored in various containers.

Many ARFs are a function of the maximum pressure realized by a container. In the absence of pressure response data, conservatively high release pressures must be assumed. This leads to higher dose estimates and expensive preventive or mitigative controls. More realistic pressure response and container failure information (i.e. leak in lieu of break) will reduce control cost and complexity.[1]

The objective for Savannah River National Lab-Separation and Actinide Science Program (SRNL-SASP) is to design and produce safe inert payloads to be used in the fire testing of PCVs which would be typical of actual PCV payloads.[2] This report discusses the development of criteria for payload production, the characterization of the powder load, and the production of payloads to be used in the fire testing.

2.0 Materials

Payload criteria were developed for the payload from specifications dictated by N&CSE. These criteria were based upon Task Order 000577-001 Appendix A (TO-577) which details the proposed fire tests[3]. The details of Pu Oxide and other components of the payload specified in TO-577 were derived from the payload described in M-CLC-H-03188 (3188).

2.1 Alumina powder

Alumina powder was used as a Plutonium Oxide (Pu Oxide) simulant. Mesh size 400 was chosen to match the particle size of typical AFS2 and 3013 materials. The alumina powder used in the production of payloads was purchased from Kramer Industries, Inc.

2.2 Moisture load

Moisture added into payloads was 18.2 MΩ•cm deionized water.

2.3 Alumina balls

Alumina balls were used to simulate the permanently displaced volume as defined in the 3188 payload. The balls are 1 inch in diameter. Alumina ceramic balls were purchased from CoorsTek Industries.

2.4 Plastic Load

The total plastic amount required for testing needed to be supplemented past the tubing used in payload productions bags. 7-inch U-line tubing used to reach the total plastic requirement. 6-inch and 7-inch wide polyethylene tubing were purchased from U-line. Both size tubing's have a thickness of 6 mil. Bags for payload preparation are formed by first heat-sealing one end of the tubing, loading material, and then heat sealing the open end.

2.5 Shipping Packaging

Protect 470 tubing was purchased from Protective Packaging Corporation. The tubing has a 7-inch flat tube. Protect 470 tubing is a 4-layered bag comprised of poly and foil layers. The tubing is only used as the protective shipping packaging and for storage of the payloads. Material has been shown to have low moisture permeation, thus preserving the moisture load in the payload during shipment and storage.

Further characterizations of the alumina materials are discussed later in this report.

3.0 Payload Preparation

3.1 Criteria Development

The first phase in the development of payloads consisted of developing the relevant criteria to be used in the design of the fire testing payloads as documented in SRNL-TR-2018-00009.[4]

- The displacement volume of the powder is based on a 1500 g load of plutonium oxide material with a pycnometric density of 4.5 g/cc
- The total amount of plastic loaded into each payload.
- The total moisture content of each payload.
- Total Free Volume of a payload. This criterion is satisfied by using the idea of a "permanent occupied volume".

These criteria are used as the minimum loading requirements for each payload. Tolerances for the loading requirements will be discussed later in this report. Secondary and tertiary tier criteria are also discussed in SRNL-TR-2018-00009.

SRNL-SASP applied these criteria to determine a suitable powder loading material. Aluminum oxide (alumina) has a theoretical density of 4.0 g/cc which is near the density of plutonium oxide specified in TO-577. Alumina is a commonly used abrasive which means it is readily available in a specific particle size range. The oxide is also non-reactive at elevated temperatures. Although alumina has not been evaluated for specified thermal characteristics, it is the most suitable material based on the second and third tier criteria.

While the original payload criteria in TO-577 were developed from 3188, these criteria were not completely consistent with the values discussed in 3188. SRNL-SASP developed criteria consistent with the 3188 payload once the inconsistencies were discovered. The single exception was the specified density of plutonium oxide, where the value in TO-577 was used.

One major inconsistency was the omission of a sufficient amount a plastic material in the TO-577 payload to represent the polyphenyl ether (getter material) present in the 3188 payload. From a gas generation basis, the amount of polyethylene in the 577 payload was increased to 163 g to match the gas generation from the total amount of plastic in the 3188 payload. The conversion and corresponding calculations can be found in Appendix A. Data used for the gas basis conversion came from 3188.

Another inconsistency was the definition of the free volume. In the 3188 payload the volume which does not undergo phase change, the permanently occupied volume, comes from steel (355 cc), zeolite (94 cc), Pu oxide (313 cc), and aluminum (331 cc), for a total of 1092 cc. In TO-577 the density of the Pu oxide was lowered from 4.8 to 4.5, giving a total permanent volume of 1113 cc. To conform with the 3188 payload, the criteria for permanently occupied volume was increased to 1113 cc of permanent occupied volume, rather than using the initial free volume of 3729 cc as defined in TO-577. Alumina balls were used in order to satisfy this requirement of permanently occupied volume. Below are the fully developed criteria used in the production of payloads for fire testing.

Table 3-1. Criteria for Payload Production

Material	Target Value
Powder Displacement Volume (cc)	333
Total Moisture (g)	111
Total Plastic (g)	163
Permanently Occupied Volume (cc)	1113

3.2 Material Characterization

3.2.1 Alumina Powder

Upon receipt, samples of alumina powder were sent to Analytical Development (AD) for characterization. All results can be found in the electronic laboratory notebook Y5528-00111-30. The following analyses were conducted on received material:

1. X-Ray Diffraction (XRD)
2. X-Ray Fluorescence (XRF)
3. Particle Size Distribution (PSD)
4. Pycnometric Density
5. Thermogravimetric Analysis-Mass Spectrometry (TGA-MS)

3.2.1.1 XRD

XRD analysis showed that Alumina and a sodium/alumina hydrate complex dominate the material composition. No other phases were detected, indicating a high purity material.

3.2.1.2 XRF

XRF analysis indicate the alkali rare earth metal components are consistent with the supplier's specifications. The trace minerals found in the sample are also consistent with typical oxide composition.

3.2.1.3 PSD

The PSD analysis was consistent with the supplier specifications. The range of particle sizes is sufficiently near that of typical plutonium oxide

3.2.1.4 Pycnometric Density

The density of the received material was determined via Helium Gas Pycnometry. The density observed was 3.9694 g/cc. This observation agrees with the theoretical density of polycrystalline alumina which is estimated to be 3.974 g/cc.[5]

3.2.1.5 TGA-MS

The gypsum calibration line of the TGA-MS has a slope of 5.78 for the time period of the powdered alumina runs. The mass spectrometer (MS) observed a value of 54.8 units of area which corresponds to 9.6 grams of moisture content. Upon dividing by the total sample mass, the moisture content of powdered alumina is found to be 0.191%.

3.2.2 Alumina Balls

The alumina balls were analyzed via Helium Gas Pycnometry to determine their density. A density of 3.8739 g/cc was observed. Results can be found in the electronic laboratory notebook Y5528-00111-30. Per the manufacturers specifications, the material is nominally 99.5wt% alumina with small amounts of crystalline silica and magnesium oxide.[6,7]

3.3 Tolerance Development

Tolerance requirements were developed to ensure the dispensed amount of each component was equal to or greater than the minimum dispensing target, or target value. Values higher than the target are conservative for fire testing, producing higher pressures. Target values are taken from the criteria set forth by NCS&E and SASP. The target values and dispensing targets can be seen in Table 3-2 below. The derivation of the dispensing targets and tolerances can be found in SRNL-TR-2018-00009.[4]

Table 3-2. Target Values and Corresponding Dispensing Targets for Payload Components

Material	Target Value (g)	Dispensing Target (g)
Alumina Powder	1322.87	1336.60
Moisture	111.00	111.82
Plastic	163.00	163.70
Alumina Balls	3019.32	3049.51-3083.81

3.4 Final Payload Preparation

Payloads were prepared using R&D Directions developed by SRLN-SASP and approved by SRNS-N&CSE.[8] A general schematic of the payload design can be seen in Appendix A. Images of the fully packaged payload can also be found in Appendix A.

The critical components and their weights in each payload are listed in Table 3-3 below.

Table 3-3. Critical Payload Component Measurements

	3188 Payload*	PL01	PL02	PL03	PL04	PL05	PL06	PL07	PL08
Alumina Powder (g)		1336.63	1336.62	1336.58	1336.87	1336.64	1336.79	1336.67	1336.66
Alumina Powder (cc)	333	336.80	336.80	336.79	336.86	336.80	336.84	336.81	336.81
Total Water (g)	111	111.76	111.9	111.78	111.69	111.63	111.69	111.68	111.72
Alumina Balls (g)		3058.64	3057.64	3061.32	3061.8	3054.17	3059.19	3060.55	3082.26
Alumina Balls (cc)		789.55	789.29	790.24	790.37	788.40	789.69	790.04	795.65
Total Plastic (g)	163	161.89	163.04	163.09	163.45	163.21	163.31	163.41	163.81
Permanent Occupied Volume (cc)	1113	1126.35	1126.09	1127.03	1127.23	1125.20	1126.53	1126.86	1132.46
Total Payload Weight (g)		4668.9	4669.2	4672.8	4673.8	4665.7	4671.0	4672.3	4694.5

*These values are calculated using a Pu Oxide density of 4.5 g/cc as in TO-577 instead of the 4.8 g/cc used in 3188 per N&CSE direction

Payload PL01 is 1.11 g shy of the agreed upon target value for total plastic loading. The payload is to be used only if there's a problem with all 7 of the other payloads per the direction of N&CSE.

All weights were recorded as described in 1Q-12.1, M&TE Usage / Reverse Traceability Documentation. The worksheets used to collect all relevant data are attached in Appendix B.

3.5 Quality Assurance

Requirements for performing reviews of technical reports and the extent of review are established in manual E7 2.60. SRNL documents the extent and type of review using the SRNL Technical Report Design Checklist contained in WSRC-IM-2002-00011, Rev. 2.

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Appendix A. TO-577 Corrections and Corresponding Calculations

Table A-1. TO-577 Plastic Correction

Variable	Plastic in Payload	monomer MW	mol plastic	$\frac{mol\ gas}{mol\ solid}$	mol gas
Symbol	M_p	MW_p	mol_p	$mol_{G/P}$	Mol_G
Source	3188	3188	$\frac{M_p}{MW_P}$	3188	$mol_P \times mol_{G/P}$
Units	g	g/mol	mol	-	mol
Viton GLT	7.3	330	0.022	5	0.111
Polyphenyl ether	190	446	0.426	4.19	1.785
Polyethylene	110	28	3.929	1	3.929
Totals	307.3				5.824
Equivalent Polyethylene in the 577 payload.					
Source	$\frac{mol_p}{MW_P}$	3188	$\frac{mol_G}{mol_{G/P}}$	3188	Total gas
Value	163	28	5.824	1	5.824

Outline of Plastic Conversion Calculations.

$$\boldsymbol{mol_P = \frac{M_p}{MW_P}} \quad \text{(A-1)}$$

*Do calculation for each plastic source.

$$\boldsymbol{mol_G = mol_P \times mol_{G/P}} \quad \text{(A-2)}$$

*Do calculation for each plastic source.

$$\boldsymbol{mol_G^{Total} = mol_G^{Viton\ GLT} + mol_G^{Polyphenyl\ ether} + mol_G^{Polyethylene}} \quad \text{(A-3)}$$

$$\boldsymbol{mol_P^{polyethylene} = \frac{mol_G^{Total}}{mol_{G/P}^{Polyethylene}}} \quad \text{(A-4)}$$

$$\boldsymbol{M_P^{polyethylene} = \frac{mol_P^{polyethylene}}{MW_P^{polyethylene}}} \quad \text{(A-5)}$$

Table A-2. Revised TO-577 Permanent Occupied Volume Summary

	Mass (g)	**Density (g/cc)**	**Volume (cc)**
Steel			355
Zeolite	300	3.2	94
Pu oxide	1500	4.5	333
Aluminum	899.2	2.72	331
Total Permanent Occupied Volume			**1113**

*There was no round up in this table. Minor math errors were also corrected from 3188.

Appendix B. Payload Design

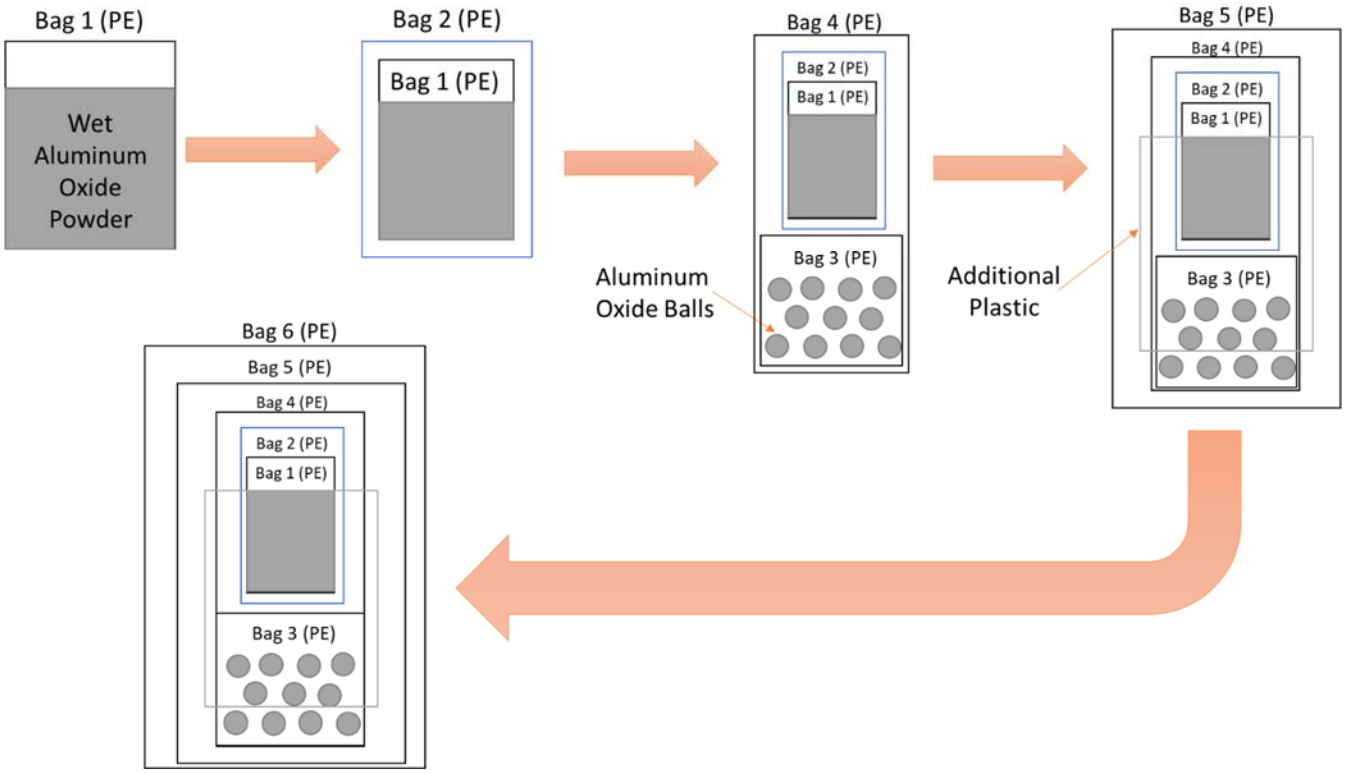

Figure B-1.General Payload Schematic.

Appendix C. Packaged Payload Images

Figure C-1. Fully prepared payload next to PCV.

Figure C-2. Fully prepared payload packaged in shipping bag.

Appendix D. Payload Production R&D Directions

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7-02-2018

PI: John Scogin
Date: _____
Work Group: Separation & Actinide Science
Reference Documents: SRNL-TR-2018-00009; SRNL-RP-2017-00762; SRNL-L3100-2016-00110; Manual 2S, 2.1

Hazards

Specific hazards associated with this work are airborne particles, potentially exposed hot surfaces, pinch point, and sharps. Airborne particles arise from the aluminum oxide powder, which has a small particle size. Heat and a pinch point are hazards are associated with the use of the heat sealer. Sharps are associated with the use of scissors to cut bags.

Hazard Controls

General hazards associated with this work are covered under 8Q, 26. PPE (lab coat, gloves, safety glasses) will be worn while working in the lab. Aluminum oxide powder is non-hazardous and requires no special precautions per SDS 51682-1. The dust produced by aluminum oxide is controlled by conducting all dry powder work in an approved chemical hood per L1, 3.13, Rev 14, pg. 14 or a properly ventilated lab (SDS 51682-1, SRNL-L3100-2016-00110). The hazards presented by the heat sealer are mitigated by limiting use of the heat sealer to those workers properly trained in its operation. Hazards and mitigations for the heat sealer are covered in SRNL-ACT-0718 to use heat sealer. Sharp hazards are controlled via Procedure 8Q, 26. Only a single person will hold bag and cut when using scissors. If two people are necessary to cut bags, leather gloves will be worn by the person holding the workpiece.

Information

Weighings must be performed as described in 1Q-12.1, M&TE Usage / Reverse Traceability Documentation

Several redundant weighings (e.g. cuff weights) are performed for cross-checking purposes.

Waste

All waste generated during this process is covered by Procedure 3Q, 6.2, Section 5.1.4 and EEC TC-A-2016-006.

Set-Up

The following items must be addressed before any work is conducted:

- Ensure M&TE calibrations to open both the balances inside and outside of the hood have been performed prior to starting packaging for each day.
- Ensure the alumina is in an approved hood before opening
- Test the heat sealer settings on a practice bag. Heat sealer settings can vary from day to day.
- Nitrile gloves will be worn to avoid the transfer of any stray mass to the payload.

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Directions

Notes:

- Bags are numbered from inner to outer (i.e. Bag 1 is the innermost, Bag 2 contains Bag 1, etc.)
- All weights will be recorded using three-way verification per Manual 2S, 2.1

1. Cut all bags from plastic tubing and heat seal one end of each bag. Bag dimensions can be found in Table II of the Worksheet.
2. Cut cuff to be used for powder weighing.
    a. 7 inch wide tubing, 9 to 12 inches long are suggested dimensions.
3. Make labels of Payload ID for Bag 6 and Mylar bag.
    a. Payload ID labels, "Tear Here to Open" labels
4. Weight empty Bag 1 outside of the hood. Record weight
5. Weigh unused plastic Cuff on balance inside the hood. Record weight.
6. Weigh approximately 108 g of water outside the hood in an appropriately sized beaker.
7. Place Bag 1 inside of the holder. Cuff the top portion of Bag 1 inside the edges of the holder.
8. Place plastic Cuff over the edge of the holder and into Bag 1.
    a. The Cuff will prevent alumina from adhering to the upper portion of the bag which can cause issues with the final heat seal.
9. Weigh [Bag 1 + Holder + Lid + Cuff] on the balance outside of the hood. Record weight.
    a. Tare Balance with the load on the balance.
10. Weigh [Bag 1 + Holder + Cuff] on the balance inside of the hood. Record weight
    a. Tare Balance with the load on the balance.
11. Add alumina to Bag 1 until the dispensing target weight is hit. (See dispensing target attachment). Pause occasionally to tap down the powder.
12. Place the lid on the [Bag 1+ Powder + Holder + Cuff].
13. Transfer bag 1 to the balance outside of the hood.
14. Record the weight of alumina powder added on balance outside hood.
15. Remove the load from the balance.
16. Zero the balance
17. Weigh [Bag 1 + Powder + Holder + Cuff + Lid] outside of the hood. Record weight.
    a. Tare balance with the load on the balance.
18. Transfer the [Bag 1+ Powder + Holder + Cuff + Lid] back to the balance inside the hood and remove the lid.
19. Tare balance inside the hood.
20. Slowly pour the water into the powder using a funnel.
21. Ensure the water has settled.
22. Weigh the [Bag 1 + Powder + Holder + Cuff + Water] inside the hood. Record weight.
23. Calculate the required amount of **additional** water. Record number. (See dispensing target attachment)
24. Add the remainder of the water via pipette until the dispensing target weight has been reached.
25. Place the lid back on the holder. Transfer to the balance outside of the hood and record the weight.
26. Transfer the [Bag 1+ Powder + Holder + Cuff + Lid] back to the hood and remove the lid.
27. Carefully remove Cuff from Bag 1 inside hood. Gently tap powder from cuff back into bag during the removal process.

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28. Zero balance inside hood.
29. Weigh used Cuff on balance inside of the hood. Record weight.
30. Carefully remove Bag 1 from the holder in the hood to ensure no powder or moisture is lost.

Note: All work may now be conducted outside of the hood, including all weight measurements.

31. Be sure to burp out as much air as possible from Bag 1 before heat sealing.
32. Heat seal Bag 1 across the top of the bag.
33. Zero Balance
34. Weigh sealed Bag 1. Record weight.
35. Weigh empty Bag 2. Record weight.
36. Place sealed Bag 1 and all of its contents into Bag 2.
37. Heat seal Bag 2 across the top of the bag.
38. Weigh the double bagged load and record the weight.
39. Weigh empty Bag 3. Record weight.
40. Wipe holder if necessary.
41. Place Bag 3 inside of holder. Tare balance with [Bag 3 + Holder].
42. Add alumina balls until dispensing target is hit.
43. Record the weight of alumina balls added.
44. Heat seal Bag 3 across the top of the bag.
    a. Bag 3 will now be referred to as the alumina ball bag.
45. Zero Balance
46. Weigh bag 3 with the alumina balls. Record weight.
47. Weigh empty Bag 4. Record weight.
48. Place the alumina ball bag and the double bagged powder load into Bag 4.
49. Heat seal Bag 4 across the top of the bag.
50. Weigh sealed Bag 4. Record weight.
51. Place payload label on Bag 6.
52. Place Bag 5 and Bag 6 on the balance with sealed Bag 4. Record weight.
53. Calculate the amount of additional plastic needed to reach the dispensing target weight. Record in data sheet.
54. Weigh out extra plastic. Record weight.
55. Weigh empty Bag 5. Record weight.
56. Either place extra plastic in the bottom of Bag 5 or wrap extra plastic around bag 4.
57. Place Bag 4 inside of Bag 5.
58. Heat seal Bag 5 across the top of the bag.
59. Weigh sealed Bag 5. Record weight.
60. Weigh empty Bag 6. Record weight.
61. Place Bag 5 into Bag 6.
62. Heat seal Bag 6 across the top of the bag.
63. Weigh sealed Bag 6. Record weight.
64. Test bag 6 in PCV for fit
65. Place the payload inside of the Mylar bag and heat seal across the top.
66. Place a payload label on the outside of the Mylar bag. Cut tear notch above the heat seal on bag 6. Label the notch "TEAR HERE TO OPEN".
67. Verify the M&TE calibrations to close the balances inside and outside of the hood

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Table I. Dispensing Targets

	Dispensing Target (g)
Powder Load	1336.60
Plastic Load	163.70
Moisture Load	111.82
Ball Load	3049.51 - 3083.81
Final Payload	4678.08

Table II. Bag Dimensions

Bag #	Width (in)	Length (in)
1	6	12
Cuff	7	9 - 12
2	6	12
3	6	14
4	6	22
5	7	22
6	7	22

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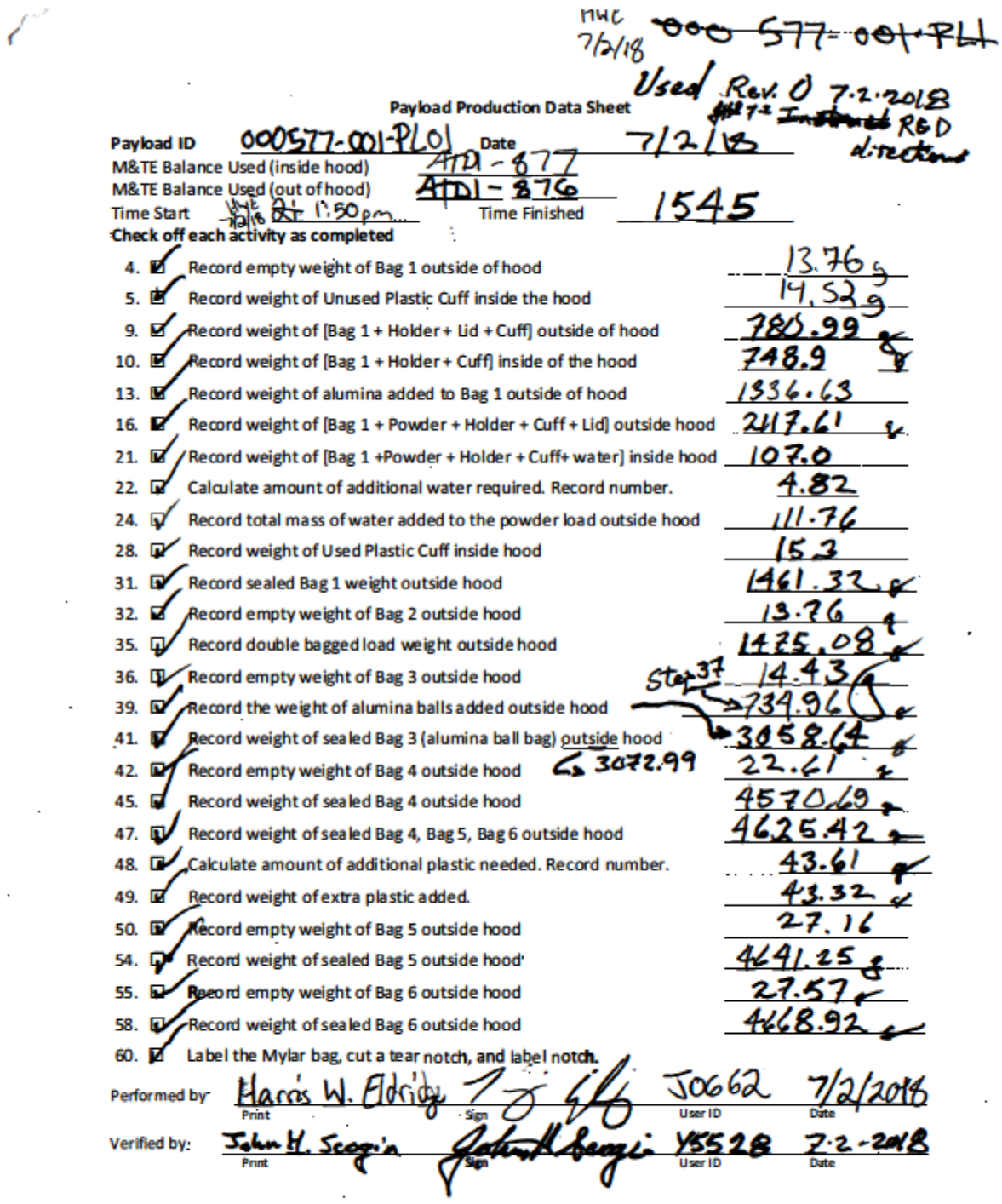
Payload Production Data Sheet

Payload ID _____ **Date** _____
M&TE Balance Used (inside hood) _____
M&TE Balance Used (out of hood) _____
Time Start _____ Time Finished _____
Check off each activity as completed

	☐	Record empty weight of Bag 1 outside of hood	_____
5.	☐	Record weight of Unused Plastic Cuff inside the hood	_____
9.	☐	Record weight of [Bag 1 + Holder + Lid + Cuff] outside of hood	_____
10.	☐	Record weight of [Bag 1 + Holder + Cuff] inside of the hood	_____
14.	☐	Record weight of alumina added to Bag 1 outside of hood	_____
17.	☐	Record weight of [Bag 1 + Powder + Holder + Cuff + Lid] outside hood	_____
22.	☐	Record weight of [Bag 1 +Powder + Holder + Cuff+ water] inside hood	_____
23.	☐	Calculate amount of additional water required. Record number.	_____
25.	☐	Record total mass of water added to the powder load outside hood	_____
29.	☐	Record weight of Used Plastic Cuff inside hood	_____
33.	☐	Record sealed Bag 1 weight outside hood	_____
35	☐	Record empty weight of Bag 2 outside hood	_____
38.	☐	Record double bagged load weight outside hood	_____
39.	☐	Record empty weight of Bag 3 outside hood	_____
43.	☐	Record the weight of alumina balls added outside hood	_____
45.	☐	Record weight of sealed Bag 3 (alumina ball bag) outside hood	_____
47.	☐	Record empty weight of Bag 4 outside hood	_____
50.	☐	Record weight of sealed Bag 4 outside hood	_____
52.	☐	Record weight of sealed Bag 4, Bag 5, Bag 6 outside hood	_____
53.	☐	Calculate amount of additional plastic needed. Record number.	_____
54.	☐	Record weight of extra plastic added.	_____
55.	☐	Record empty weight of Bag 5 outside hood	_____
59.	☐	Record weight of sealed Bag 5 outside hood	_____
60.	☐	Record empty weight of Bag 6 outside hood	_____
63.	☐	Record weight of sealed Bag 6 outside hood	_____
66.	☐	Label the Mylar bag, cut a tear notch, and label notch.	

Performed by:	_____ Print	_____ Sign	_____ User ID	_____ Date
Verified by:	_____ Print	_____ Sign	_____ User ID	_____ Date

Appendix E. Payload Worksheets



mwc 7/2/18 000577-001-PL01 Used Rev. 0 7.2.2018 Add 7-2 Instructed R&D directions

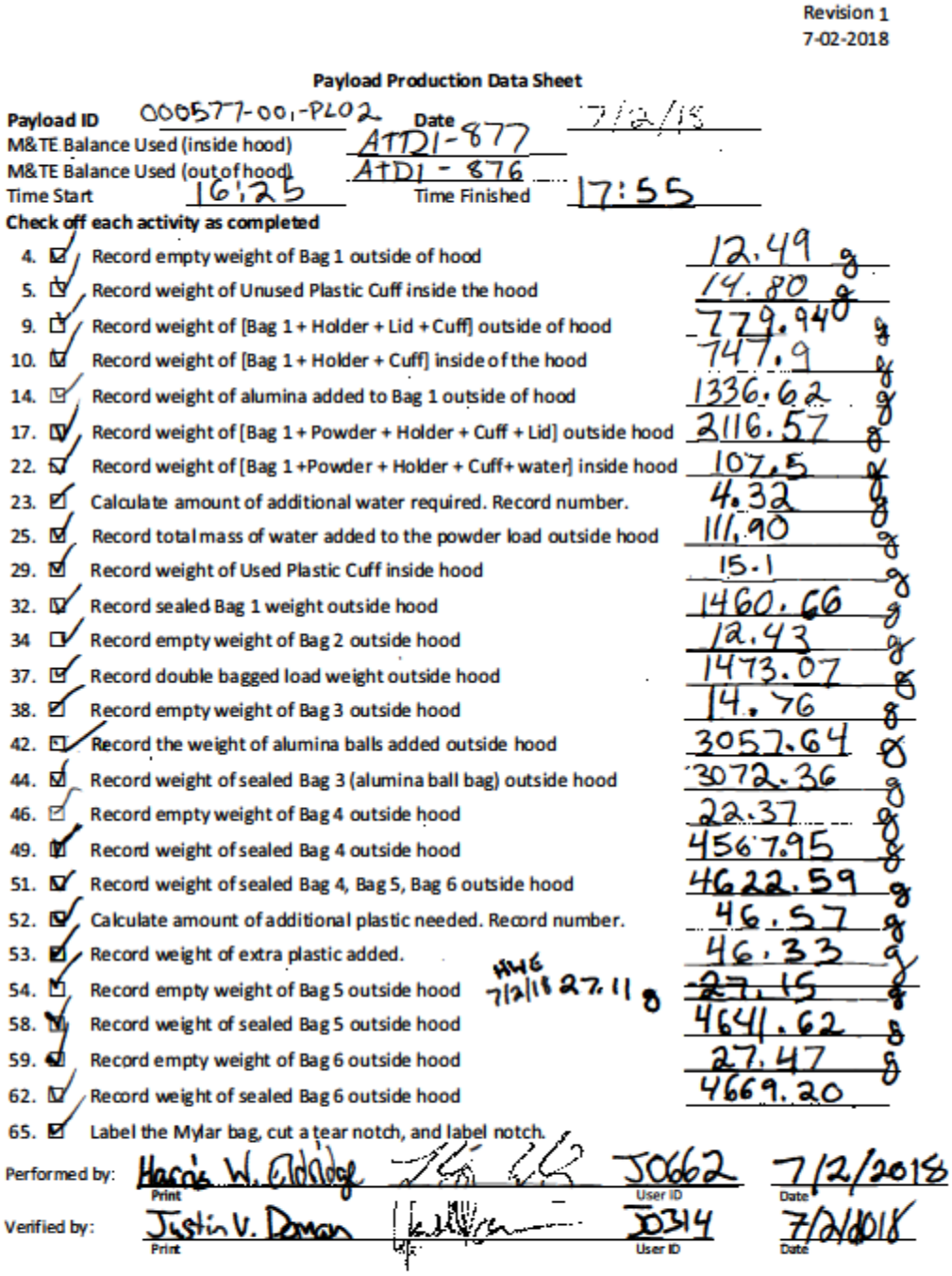
Payload Production Data Sheet

Payload ID 000577-001-PL01 **Date** 7/2/18
M&TE Balance Used (inside hood) ATI-877
M&TE Balance Used (out of hood) ATI-876
Time Start 1250 Est 1:50pm Time Finished 1545
Check off each activity as completed

4.	☑	Record empty weight of Bag 1 outside of hood	13.76 g
5.	☑	Record weight of Unused Plastic Cuff inside the hood	14.52 g
9.	☑	Record weight of [Bag 1 + Holder + Lid + Cuff] outside of hood	780.99 g
10.	☑	Record weight of [Bag 1 + Holder + Cuff] inside of the hood	748.9 g
13.	☑	Record weight of alumina added to Bag 1 outside of hood	1336.63
16.	☑	Record weight of [Bag 1 + Powder + Holder + Cuff + Lid] outside hood	2117.61 g
21.	☑	Record weight of [Bag 1 +Powder + Holder + Cuff+ water] inside hood	107.0
22.	☑	Calculate amount of additional water required. Record number.	4.82
24.	☑	Record total mass of water added to the powder load outside hood	111.76
28.	☑	Record weight of Used Plastic Cuff inside hood	15.3
31.	☑	Record sealed Bag 1 weight outside hood	1461.32 g
32.	☑	Record empty weight of Bag 2 outside hood	13.76 g
35.	☑	Record double bagged load weight outside hood	1475.08 g
36.	☑	Record empty weight of Bag 3 outside hood	Step 37 14.43 g
39.	☑	Record the weight of alumina balls added outside hood	734.96 g
41.	☑	Record weight of sealed Bag 3 (alumina ball bag) outside hood	3058.14 g
42.	☑	Record empty weight of Bag 4 outside hood	3072.99 22.61 g
45.	☑	Record weight of sealed Bag 4 outside hood	4570.69 g
47.	☑	Record weight of sealed Bag 4, Bag 5, Bag 6 outside hood	4625.42 g
48.	☑	Calculate amount of additional plastic needed. Record number.	43.61 g
49.	☑	Record weight of extra plastic added.	43.32 g
50.	☑	Record empty weight of Bag 5 outside hood	27.16
54.	☑	Record weight of sealed Bag 5 outside hood	4641.25 g
55.	☑	Record empty weight of Bag 6 outside hood	27.57 g
58.	☑	Record weight of sealed Bag 6 outside hood	4668.92 g
60.	☑	Label the Mylar bag, cut a tear notch, and label notch.	

Performed by: Harris W. Aldridge (Print) (Sign) J0662 (User ID) 7/2/2018 (Date)
Verified by: John H. Scoggins (Print) (Sign) Y5528 (User ID) 7-2-2018 (Date)

Figure E-1. PL01 Worksheet



Revision 1
7-02-2018

Payload Production Data Sheet

Payload ID 000577-001-PL02 **Date** 7/2/18
M&TE Balance Used (inside hood) ATDI-877
M&TE Balance Used (out of hood) ATDI-876
Time Start 16:25 Time Finished 17:55

Check off each activity as completed

4.	☑	Record empty weight of Bag 1 outside of hood	12.49 g
5.	☑	Record weight of Unused Plastic Cuff inside the hood	14.80 g
9.	☑	Record weight of [Bag 1 + Holder + Lid + Cuff] outside of hood	779.94 g
10.	☑	Record weight of [Bag 1 + Holder + Cuff] inside of the hood	747.9 g
14.	☑	Record weight of alumina added to Bag 1 outside of hood	1336.62 g
17.	☑	Record weight of [Bag 1 + Powder + Holder + Cuff + Lid] outside hood	2116.57 g
22.	☑	Record weight of [Bag 1 +Powder + Holder + Cuff+ water] inside hood	107.5 g
23.	☑	Calculate amount of additional water required. Record number.	4.32 g
25.	☑	Record total mass of water added to the powder load outside hood	111.90 g
29.	☑	Record weight of Used Plastic Cuff inside hood	15.1 g
32.	☑	Record sealed Bag 1 weight outside hood	1460.66 g
34	☑	Record empty weight of Bag 2 outside hood	12.43 g
37.	☑	Record double bagged load weight outside hood	1473.07 g
38.	☑	Record empty weight of Bag 3 outside hood	14.76 g
42.	☑	Record the weight of alumina balls added outside hood	3057.64 g
44.	☑	Record weight of sealed Bag 3 (alumina ball bag) outside hood	3072.36 g
46.	☑	Record empty weight of Bag 4 outside hood	22.37 g
49.	☑	Record weight of sealed Bag 4 outside hood	4567.95 g
51.	☑	Record weight of sealed Bag 4, Bag 5, Bag 6 outside hood	4622.59 g
52.	☑	Calculate amount of additional plastic needed. Record number.	46.57 g
53.	☑	Record weight of extra plastic added.	46.33 g
54.	☑	Record empty weight of Bag 5 outside hood HH6 7/2/18 27.11 g	27.15 g
58.	☑	Record weight of sealed Bag 5 outside hood	4641.62 g
59.	☑	Record empty weight of Bag 6 outside hood	27.47 g
62.	☑	Record weight of sealed Bag 6 outside hood	4669.20
65.	☑	Label the Mylar bag, cut a tear notch, and label notch.	

Performed by: Harris W. Eddridge (Print) JO662 (User ID) 7/2/2018 (Date)
Verified by: Justin V. Doman (Print) JO314 (User ID) 7/2/2018 (Date)

Figure E-2. PL02 Worksheet

Revision 1
7-02-2018

Payload Production Data Sheet

Payload ID 000577-001-PL03 Date 7/3/18
M&TE Balance Used (inside hood) 35026
M&TE Balance Used (out of hood) 35048
Time Start 12:30 Time Finished 14:05
Check off each activity as completed

4.	☐	Record empty weight of Bag 1 outside of hood	12.67 g
5.	☐	Record weight of Unused Plastic Cuff inside the hood	15.50 g
9.	☐	Record weight of [Bag 1 + Holder + Lid + Cuff] outside of hood	780.91 g
10.	☐	Record weight of [Bag 1 + Holder + Cuff] inside of the hood	748.8 g
14.	☐	Record weight of alumina added to Bag 1 outside of hood	1336.58 g
17.	☐	Record weight of [Bag 1 + Powder + Holder + Cuff + Lid] outside hood	2117.51 g
22.	☐	Record weight of [Bag 1 +Powder + Holder + Cuff+ water] inside hood	107.7 g
23.	☐	Calculate amount of additional water required. Record number.	4.12 g
25.	☐	Record total mass of water added to the powder load outside hood	111.78 g
29.	☐	Record weight of Used Plastic Cuff inside hood	16.0 g
33.	☐	Record sealed Bag 1 weight outside hood	1460.62 g
35	☐	Record empty weight of Bag 2 outside hood	12.48 g
38.	☐	Record double bagged load weight outside hood	1493.70 g
39.	☐	Record empty weight of Bag 3 outside hood	14.52 g
43.	☐	Record the weight of alumina balls added outside hood	3061.32 g
45.	☐	Record weight of sealed Bag 3 (alumina ball bag) outside hood	3075.81 g
47.	☐	Record empty weight of Bag 4 outside hood	22.96 g
50.	☐	Record weight of sealed Bag 4 outside hood	4571.93 g
52.	☐	Record weight of sealed Bag 4, Bag 5, Bag 6 outside hood	4626.96 g
53.	☐	Calculate amount of additional plastic needed. Record number.	45.72 g
54.	☐	Record weight of extra plastic added.	45.72 g
55.	☐	Record empty weight of Bag 5 outside hood	27.37 g
59.	☐	Record weight of sealed Bag 5 outside hood	4645.25 g
60.	☐	Record empty weight of Bag 6 outside hood	27.67 g
63.	☐	Record weight of sealed Bag 6 outside hood	4672.77 g
66.	☐	Label the Mylar bag, cut a tear notch, and label notch.	

Performed by: Harris W. Eldridge (Print) [signature] (Sign) J0662 (User ID) 7/03/2018 (Date)
Verified by: Betty Y. Mealer (Print) [signature] (Sign) W7300 (User ID) 7/03/2018 (Date)

Figure E-3. PL03 Worksheet

Revision 1
7-02-2018

Payload Production Data Sheet

Payload ID 000577-001-PL04 Date 7/03/2018
M&TE Balance Used (inside hood) 35026
M&TE Balance Used (out of hood) 35048
Time Start 1413 Time Finished 1526
Check off each activity as completed

4.	☐	Record empty weight of Bag 1 outside of hood	12.64g
5.	☐	Record weight of Unused Plastic Cuff inside the hood	15.1 g
9.	☐	Record weight of [Bag 1 + Holder + Lid + Cuff] outside of hood	780.37g
10.	☐	Record weight of [Bag 1 + Holder + Cuff] inside of the hood	748.3 g
14.	☐	Record weight of alumina added to Bag 1 outside of hood	1336.87g
17.	☐	Record weight of [Bag 1 + Powder + Holder + Cuff + Lid] outside hood	2117.31g
22.	☐	Record weight of [Bag 1 +Powder + Holder + Cuff+ water] inside hood	108.0 g
23.	☐	Calculate amount of additional water required. Record number.	3.82g
25.	☐	Record total mass of water added to the powder load outside hood	111.64g
29.	☐	Record weight of Used Plastic Cuff inside hood	15.6 g
33.	☐	Record sealed Bag 1 weight outside hood	1460.54g
35	☐	Record empty weight of Bag 2 outside hood	12.69g
38.	☐	Record double bagged load weight outside hood	1473.23g
39.	☐	Record empty weight of Bag 3 outside hood	14.78g
43.	☐	Record the weight of alumina balls added outside hood	3061.80g
45.	☐	Record weight of sealed Bag 3 (alumina ball bag) outside hood	3076.52g
47.	☐	Record empty weight of Bag 4 outside hood	23.07g
50.	☐	Record weight of sealed Bag 4 outside hood	4572.70g
52.	☐	Record weight of sealed Bag 4, Bag 5, Bag 6 outside hood	4627.11g
53.	☐	Calculate amount of additional plastic needed. Record number.	46.25g
54.	☐	Record weight of extra plastic added.	46.29g
55.	☐	Record empty weight of Bag 5 outside hood	26.97g
59.	☐	Record weight of sealed Bag 5 outside hood	4646.49g
60.	☐	Record empty weight of Bag 6 outside hood	27.35g
63.	☐	Record weight of sealed Bag 6 outside hood	4673.81g
66.	☐	Label the Mylar bag, cut a tear notch, and label notch.	

Performed by: Print Harris W. Eldridge Sign [signature] User ID J0662 Date 7/03/2018
Verified by: Print Betty Y. Mealer Sign [signature] User ID W7300 Date 7/03/2018

Figure E-4. PL04 Worksheet

Revision 1
7-02-2018

Payload Production Data Sheet

Payload ID 000577-001-PL05 Date 7/03/2018
M&TE Balance Used (inside hood) 35026
M&TE Balance Used (out of hood) 35048
Time Start 15:55 Time Finished

Check off each activity as completed

4.	☑	Record empty weight of Bag 1 outside of hood	11.91 g
5.	☑	Record weight of Unused Plastic Cuff inside the hood.	14.8 g
9.	☑	Record weight of [Bag 1 + Holder + Lid + Cuff] outside of hood	779.44 g
10.	☑	Record weight of [Bag 1 + Holder + Cuff] inside of the hood	747.3 g
14.	☑	Record weight of alumina added to Bag 1 outside of hood	1336.64 g
17.	☑	Record weight of [Bag 1 + Powder + Holder + Cuff + Lid] outside hood	2116.09 g
22.	☑	Record weight of [Bag 1 +Powder + Holder + Cuff+water] inside hood	107.9 g
23.	☑	Calculate amount of additional water required. Record number.	3.92 g
25.	☑	Record total mass of water added to the powder load outside hood	111.63 g
29.	☑	Record weight of Used Plastic Cuff inside hood	15.4 g
33.	☑	Record sealed Bag 1 weight outside hood	1459.45 g
35	☑	Record empty weight of Bag 2 outside hood	12.46 g
38.	☑	Record double bagged load weight outside hood	1471.91 g
39.	☑	Record empty weight of Bag 3 outside hood	14.69 g
43.	☑	Record the weight of alumina balls added outside hood	3054.17 g
45.	☑	Record weight of sealed Bag 3 (alumina ball bag) outside hood	3068.83 g
47.	☑	Record empty weight of Bag 4 outside hood	22.92 g
50.	☑	Record weight of sealed Bag 4 outside hood	4563.68 g
52.	☑	Record weight of sealed Bag 4, Bag 5, Bag 6 outside hood	4618.75 g
53.	☑	Calculate amount of additional plastic needed. Record number.	46.69 g
54.	☑	Record weight of extra plastic added.	46.58 g
55.	☑	Record empty weight of Bag 5 outside hood	
59.	☑	Record weight of sealed Bag 5 outside hood	4637.85 g
60.	☑	Record empty weight of Bag 6 outside hood	27.71 g
63.	☑	Record weight of sealed Bag 6 outside hood	4665.65 g
66.	☐	Label the Mylar bag, cut a tear notch, and label notch.	

Performed by: Hans W Eldridge (Print) (Sign) J0662 (User ID) 7/03/2018 (Date)
Verified by: Nicholas Karay (Print) (Sign) L6392 (User ID) 7/3/2018 (Date)

Figure E-5. PL05 Worksheet

Revision 1
7-02-2018

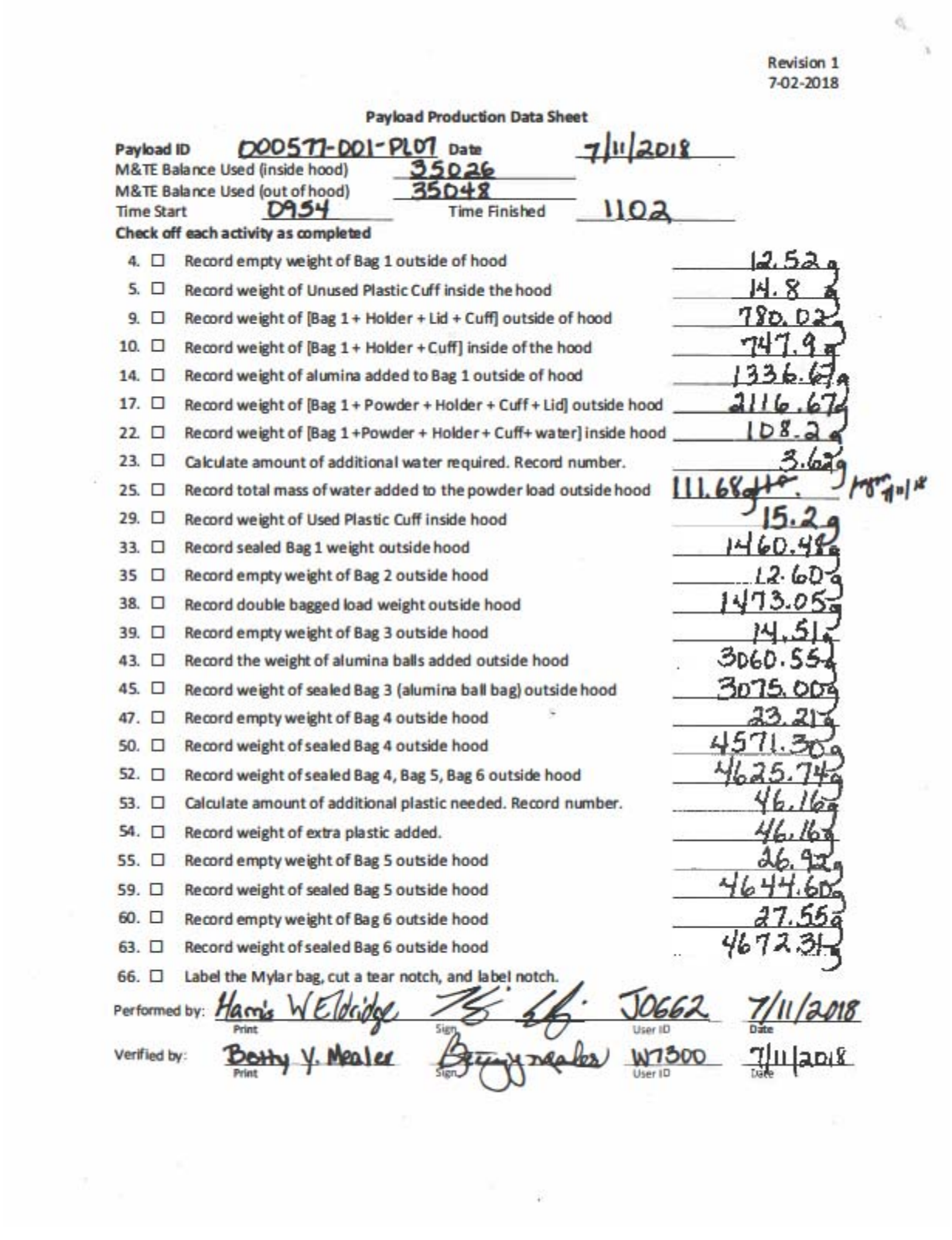
Payload Production Data Sheet

Payload ID 000577-001-PL06 **Date** 7/11/2018
M&TE Balance Used (inside hood) 35026
M&TE Balance Used (out of hood) 35048
Time Start 0730 Time Finished 0940
Check off each activity as completed

4.	☐	Record empty weight of Bag 1 outside of hood	12.47g
5.	☐	Record weight of Unused Plastic Cuff inside the hood	14.80g
9.	☐	Record weight of [Bag 1 + Holder + Lid + Cuff] outside of hood	779.99g
10.	☐	Record weight of [Bag 1 + Holder + Cuff] inside of the hood	747.9g
14.	☐	Record weight of alumina added to Bag 1 outside of hood	1336.79g
17.	☐	Record weight of [Bag 1 + Powder + Holder + Cuff + Lid] outside hood	2116.80g
22.	☐	Record weight of [Bag 1 +Powder + Holder + Cuff+ water] inside hood	107.8g
23.	☐	Calculate amount of additional water required. Record number.	4.02g
25.	☐	Record total mass of water added to the powder load outside hood	111.69g
29.	☐	Record weight of Used Plastic Cuff inside hood	15.7g
33.	☐	Record sealed Bag 1 weight outside hood	460.16g
35	☐	Record empty weight of Bag 2 outside hood	12.55g
38.	☐	Record double bagged load weight outside hood	1472.73g
39.	☐	Record empty weight of Bag 3 outside hood	14.10g
43.	☐	Record the weight of alumina balls added outside hood	3059.19g
45.	☐	Record weight of sealed Bag 3 (alumina ball bag) outside hood	3073.85g
47.	☐	Record empty weight of Bag 4 outside hood	23.10g
50.	☐	Record weight of sealed Bag 4 outside hood	4569.68g
52.	☐	Record weight of sealed Bag 4, Bag 5, Bag 6 outside hood	4625.13g
53.	☐	Calculate amount of additional plastic needed. Record number.	45.54g
54.	☐	Record weight of extra plastic added.	45.55g
55.	☐	Record empty weight of Bag 5 outside hood	27.35g
59.	☐	Record weight of sealed Bag 5 outside hood	4642.80g
60.	☐	Record empty weight of Bag 6 outside hood	28.16g
63.	☐	Record weight of sealed Bag 6 outside hood	4670.98g
66.	☐	Label the Mylar bag, cut a tear notch, and label notch.	

Performed by: Harris W Eldridge (Print) [signature] (Sign) J0662 (User ID) 7/11/2018 (Date)
Verified by: Betty Y Mealer (Print) [signature] (Sign) W7300 (User ID) 7/11/2018 (Date)

Figure E-6. PL06 Worksheet



Revision 1
7-02-2018

Payload Production Data Sheet

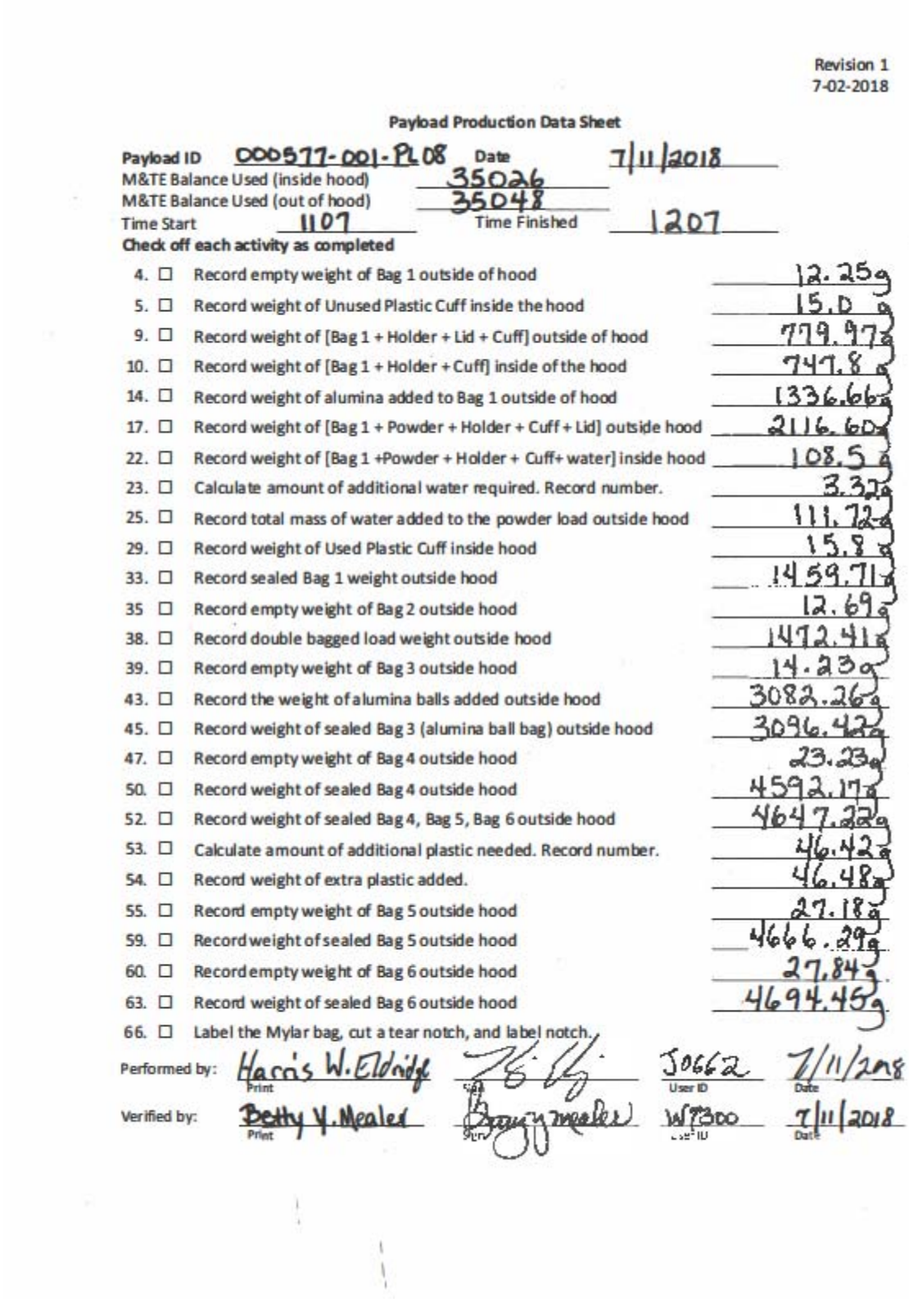
Payload ID D00577-001-PL07 Date 7/11/2018
M&TE Balance Used (inside hood) 35026
M&TE Balance Used (out of hood) 35048
Time Start 0954 Time Finished 1102

Check off each activity as completed

4.	☐	Record empty weight of Bag 1 outside of hood	12.52 g
5.	☐	Record weight of Unused Plastic Cuff inside the hood	14.8 g
9.	☐	Record weight of [Bag 1 + Holder + Lid + Cuff] outside of hood	780.02 g
10.	☐	Record weight of [Bag 1 + Holder + Cuff] inside of the hood	747.9 g
14.	☐	Record weight of alumina added to Bag 1 outside of hood	1336.67 g
17.	☐	Record weight of [Bag 1 + Powder + Holder + Cuff + Lid] outside hood	2116.67 g
22.	☐	Record weight of [Bag 1 +Powder + Holder + Cuff+ water] inside hood	108.2 g
23.	☐	Calculate amount of additional water required. Record number.	3.62 g
25.	☐	Record total mass of water added to the powder load outside hood	111.68 g
29.	☐	Record weight of Used Plastic Cuff inside hood	15.2 g
33.	☐	Record sealed Bag 1 weight outside hood	1460.48 g
35	☐	Record empty weight of Bag 2 outside hood	12.60 g
38.	☐	Record double bagged load weight outside hood	1473.05 g
39.	☐	Record empty weight of Bag 3 outside hood	14.51 g
43.	☐	Record the weight of alumina balls added outside hood	3060.55 g
45.	☐	Record weight of sealed Bag 3 (alumina ball bag) outside hood	3075.00 g
47.	☐	Record empty weight of Bag 4 outside hood	23.21 g
50.	☐	Record weight of sealed Bag 4 outside hood	4571.30 g
52.	☐	Record weight of sealed Bag 4, Bag 5, Bag 6 outside hood	4625.74 g
53.	☐	Calculate amount of additional plastic needed. Record number.	46.16 g
54.	☐	Record weight of extra plastic added.	46.16 g
55.	☐	Record empty weight of Bag 5 outside hood	26.92 g
59.	☐	Record weight of sealed Bag 5 outside hood	4644.60 g
60.	☐	Record empty weight of Bag 6 outside hood	27.55 g
63.	☐	Record weight of sealed Bag 6 outside hood	4672.31 g
66.	☐	Label the Mylar bag, cut a tear notch, and label notch.	

Performed by: Hans W Eldridge (Print) (Sign) J0662 (User ID) 7/11/2018 (Date)
Verified by: Betty Y. Mealer (Print) (Sign) W7300 (User ID) 7/11/2018 (Date)

Figure E-7. PL07 Worksheet



Revision 1
7-02-2018

Payload Production Data Sheet

Payload ID 000577-001-PL08 Date 7/11/2018
M&TE Balance Used (inside hood) 35026
M&TE Balance Used (out of hood) 35048
Time Start 1107 Time Finished 1207
Check off each activity as completed

4.	☐	Record empty weight of Bag 1 outside of hood	12.25 g
5.	☐	Record weight of Unused Plastic Cuff inside the hood	15.0 g
9.	☐	Record weight of [Bag 1 + Holder + Lid + Cuff] outside of hood	779.97 g
10.	☐	Record weight of [Bag 1 + Holder + Cuff] inside of the hood	747.8 g
14.	☐	Record weight of alumina added to Bag 1 outside of hood	1336.66 g
17.	☐	Record weight of [Bag 1 + Powder + Holder + Cuff + Lid] outside hood	2116.60 g
22.	☐	Record weight of [Bag 1 +Powder + Holder + Cuff+ water] inside hood	108.5 g
23.	☐	Calculate amount of additional water required. Record number.	3.32 g
25.	☐	Record total mass of water added to the powder load outside hood	111.72 g
29.	☐	Record weight of Used Plastic Cuff inside hood	15.8 g
33.	☐	Record sealed Bag 1 weight outside hood	1459.71 g
35	☐	Record empty weight of Bag 2 outside hood	12.69 g
38.	☐	Record double bagged load weight outside hood	1472.41 g
39.	☐	Record empty weight of Bag 3 outside hood	14.23 g
43.	☐	Record the weight of alumina balls added outside hood	3082.26 g
45.	☐	Record weight of sealed Bag 3 (alumina ball bag) outside hood	3096.42 g
47.	☐	Record empty weight of Bag 4 outside hood	23.23 g
50.	☐	Record weight of sealed Bag 4 outside hood	4592.17 g
52.	☐	Record weight of sealed Bag 4, Bag 5, Bag 6 outside hood	4647.22 g
53.	☐	Calculate amount of additional plastic needed. Record number.	46.42 g
54.	☐	Record weight of extra plastic added.	46.48 g
55.	☐	Record empty weight of Bag 5 outside hood	27.18 g
59.	☐	Record weight of sealed Bag 5 outside hood	4666.29 g
60.	☐	Record empty weight of Bag 6 outside hood	27.84 g
63.	☐	Record weight of sealed Bag 6 outside hood	4694.45 g
66.	☐	Label the Mylar bag, cut a tear notch, and label notch.	

Performed by: Harris W. Eldridge (Print) [signature] J0662 (User ID) 7/11/2018 (Date)
Verified by: Betty Y. Mealer (Print) [signature] W7300 (User ID) 7/11/2018 (Date)

Figure E-8. PL08 Worksheet

Distribution:

T. B. Brown
J. M Duffey
H. W. Eldridge
N. S. Karay
J. H. Scogin
S. J. Hensel
R. A. Sprankle
M. S. Stephens
J. P. Lampert
M. L. Whitehead