

Salt Spray (Fog) Testing to ASTM B117-18

Report No.: TR02785.06-01R0
Prepared for: Ship-2-Shore
John Bower
Address: 109 – 7337 North Fraser Way
Burnaby, BC V5J 0G7
Coating
Manufacturer: Ship-2-Shore
Date Received: 12 August 2019
Date Tested: 16 August 2019 to 28 September 2019
Part Data: Coated specimens of 5 steel pipes
Equipment Used: Q-Fog Cyclic Corrosion Tester CCT-1100, Powertech asset 30853
Mettler Toledo pH meter F20, Powertech asset 34062
VWR Hydrometer, Powertech asset 33700

TEST CONDUCTED:

Salt spray testing was conducted using the Q-Fog CCT in accordance with the following standard:

- ASTM standard B117-18, “Standard Practice for Operating Salt Spray (Fog) Apparatus”

SAMPLE DESCRIPTION & PREPARATION:

The client provided specimens consisting of the substrates and coatings listed in the table, below.

Sample ID	Substrate	Coating
S2S-100 Pipe	Steel pipe	Unidentified Ship-2-Shore coating
S2S-336 Pipe	Steel pipe	Unidentified Ship-2-Shore coating
S2S-500 Pipe	Steel pipe	Unidentified Ship-2-Shore coating
S2S-1000 Pipe	Steel pipe	Unidentified Ship-2-Shore coating
X-100 Pipe	Steel pipe	Unidentified competitor coating
X-336 Pipe	Steel pipe	Unidentified competitor coating
X-500 Pipe	Steel pipe	Unidentified competitor coating
X-1000 Pipe	Steel pipe	Unidentified competitor coating

The specimen substrate materials and coatings were supplied by the client and substrates were not cleaned prior to coating. The coatings were applied to the substrate samples by Ship-2-Shore representatives, Zoran Culin and Erik Bergvinson, who then witnessed the samples’ placement inside the Q-fog chamber before commencing the salt fog test.

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TEST SOLUTION PREPARATION:

The test solution was prepared using 5 ± 1 parts by mass of sodium chloride (NaCl) and 95 parts of water. Impurity content in the sodium chloride was confirmed to be below the limits given in ASTM B117, Section 8. Adjustment to solution pH was made using analytical grade sodium hydroxide and/or analytical grade hydrochloric acid.

TEST PROCEDURE:

The test specimen was loaded into the test chamber in the orientations shown in Figure 1. The specimens were supported on inert racks in the salt spray chamber; the flat panel specimens were oriented at an angle of $20^\circ \pm 5^\circ$ inclined from vertical.

The test parameters are shown below, in Table 1.

Table 1: Test parameters

Parameter	Value
Duration	1000 hours
Start Date	16 August 2019
End Date	28 September 2019
Chamber Temperature	$35^\circ\text{C} \pm 2^\circ\text{C}$
Collected Solution pH	pH 6.5 to 7.2 (at $23^\circ\text{C} \pm 3^\circ\text{C}$)
Collected Solution Concentration	5 ± 1 part by mass NaCl to 95 ± 1 part distilled water

Chamber temperature, collected solution specific gravity, collection rate, and collected solution pH were measured every 24 hours, or up to a maximum of 96 hours when the time period spanned a weekend or holiday.

The condition of specimen IDs S2S-Pipe, X-Pipe, X-Sheet and S2S-Sheet was documented by photograph at the following approximate intervals: 100, 336, 500, and 1000 hours. At these intervals, the tape coatings were removed and the substrates were visually inspected.

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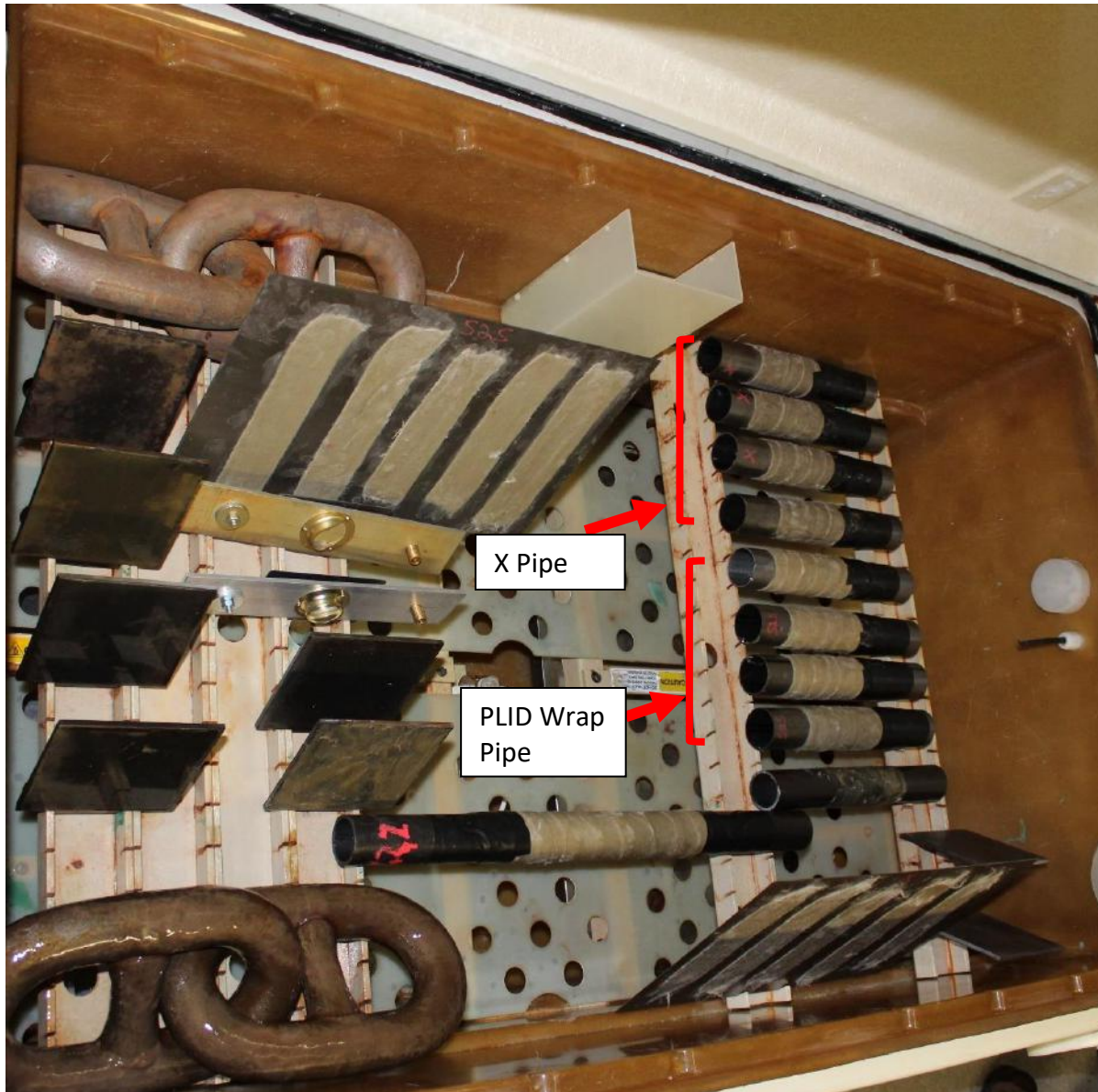


Figure 1: Inside the Q-fog chamber before starting the test

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TEST DATA:

See Appendix A for the test record.

All parameters except for collected solution pH were within the standard specification for the duration of the test. Collected solution pH remained near-neutral, but particular daily measurements were marginally below the specified pH range (minimum values of 6.0-6.3 versus 6.5-7.2). As per ASTM B117, reservoir pH adjustments were made to compensate when the collected solution pH was found to be out of specified range.

TEST RESULTS:

Test results relate only to the items tested. No acceptance criteria were provided by the client.

The wrap coatings were removed and the substrates were visually inspected and documented by photograph at the following approximate intervals: 100, 336, 500, and 1000 hours. Photographs of PLID wrap and X-pipes specimens after 100, 336, 500, and 1000 hours exposure are provided in Figures 2 through 5. After removal of the wrap coatings, examination of the PLID wrap specimens' substrates under the coatings found the specimens did not sustain corrosion, pitting, or metal loss after exposures of up to 1000 hours (Figure 3B).

Evidence of corrosion was observed on the pipe specimen substrate applied with the unidentified competitor's coatings after 100 hours (Figure 4A).

Figure 6 compares the condition of the X-Pipe and the S2S-Pipe specimens after 336 and 500 hours of exposure, respectively. No evidence of corrosion was detected on the PLID wrap pipe specimens whereas evidence of corrosion was observed on X-pipe specimens.

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A) 100 hours



B) 336 hours

Figure 2: PLID Wrap pipe specimens, after exposing to salt spray testing for approximately A) 100 and B) 336 hours.

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A) 500 hours

B) 1000 hours

Figure 3: PLID Wrap pipe specimens, after exposing to salt spray testing for approximately A) 500 and B) 1000 hours.

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A) 100 hours



B) 336 hours

Figure 4: X pipe specimens, after exposing to salt spray testing for approximately A) 100 and B) 336 hours.

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C) 500 hours



D) 1000 hours

Figure 5: X pipe specimens, after exposing to salt spray testing for approximately A) 500 and B) 1000 hours.

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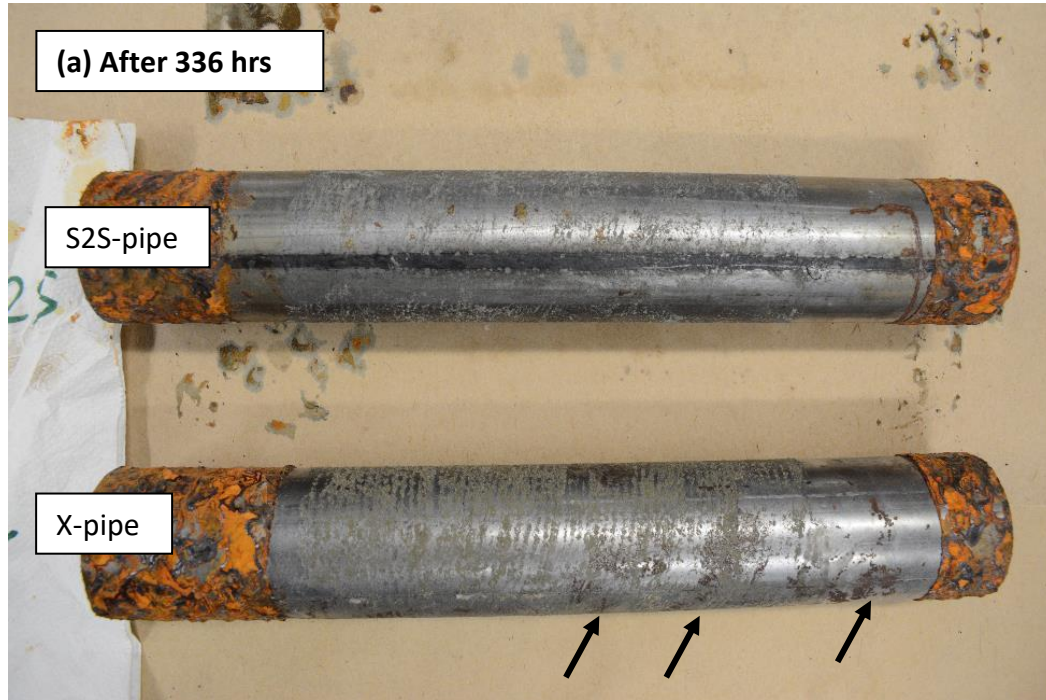


Figure 6: Evidence of corrosion on X-pipes after (a) 336 and (b) 500 hours of salt spray testing.

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Revision History

Revision 0

2019-10-25 New Document

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**APPENDIX A.
SALT FOG (SPRAY) TEST RECORD**

Salt Spray (Fog) Testing to ASTM B117-18

Powertech AMTP05 Salt Fog Test Record <small>DOC. ID: AMFT03-R3</small>						Test Standard: <input type="checkbox"/> ISO 9227:2017 <input checked="" type="checkbox"/> ASTM B117-16					
Client/PL#: <u>Ship-2-Shor PL-02785</u>						Equipment: <u>Q-Fog CCT-1100</u>					
Duration: <u>1000 hrs</u>						Asset #: <u>30853</u>					
Start Date/Time: <u>Aug 16 / 12:30 PM</u>						Cal. Due Date:					
End Date/Time: <u>Sep 27, 28</u>											
Pre- & Post-test Checks: <input checked="" type="checkbox"/> Sample condition and placement photodocumented? <input type="checkbox"/> Acceptance criteria confirmed? <u>No</u> <input checked="" type="checkbox"/> Pre-/post-test cleaning requirements confirmed/completed? <input checked="" type="checkbox"/> Pre-test collection rate test complete (req. for ISO 9227)? <input type="checkbox"/> N/A						Start of Test Checks: Atomizing air check: <u>14.5 (100)</u> Pressure, kPa (psi) <u>35°C</u> Temperature, °C <input type="checkbox"/> Pass <input type="checkbox"/> Fail					
Solution Type ¹	Date	Time	Solution Temp (°C)	Specific Gravity ²	pH	Collected Vol (mL)	Mass Check ³ (g/hr)	Elapsed Test Time (hr)	Collection Rate (mL/hr)	Chamber Temp (°C)	Initial
Re-test											
(L)	Aug 9	3:00	24.9	1.038	6.31	17		11 hrs	1.545	35	SK
(R)	Aug 9, 2019	3:05	24.8	1.037	6.36	17.6		11 hrs	1.6	35	SK
Res	Aug 16, 2019	12:30	23.8	1.030	6.67	←					SK
(R)	Aug 19, 2019	2:30	26.00	1.032 ^{25.3}	6.55	102		76 ⁵⁵⁸⁴⁵	1.34	35	SK
(L)	Aug 19, 2019	2:30	23.9	1.032 ^{24.8}	6.57	80		76 ⁵⁵⁸⁴⁵	1.052	35	SK
R	"	3:00	25.7	1.029 ^{24.5}	6.97	←					→
(R)	Aug 20, 2019	3:45	24.6	1.033 ^{24.4}	6.05	42		55870		35	SK
(L)	Aug 20, 2019	3:45	24.4	1.033 ^{24.4}	6.16	28		55870		35	SK
R	"	3:50	25.1	1.030 ^{24.5}	7.01	←					→
(R)	Aug 21, 2019	3:00	24.7	1.032	6.60	27		55893	1.174	35	
(L)	Aug 21, 2019	3:00	24.0	1.033	6.50	39		55893	1.695	35	
(R)	Aug 22, 2019	3:00	24.6	1.034 ^{24.1}	6.45	38		55917	1.583		
(L)	Aug 22, 2019	3:00	25.2	1.034 ^{24.1}	6.42	24		65917	1.00		
Res		3:30	22.7	1.029	6.54						
			23.8		6.59						
(R)	Aug 23	1:00	25.0	1.034	6.48	32		55939	1.454	35	SK
(L)	Aug 23	1:00	24.6	1.034	6.41	21		55939	0.954	35	SK

Notes:

1 Solution Type: P = Prepared, R = Reservoir, C = Collected

2 Column typically contains SG values not corrected for hydrometer offset. If SG value is outside the accepted range of 1.027 - 1.033, also report the corrected value using the notation convention: SG_{uncorrected} (SG_{corrected})

3 Report the mass/hour value for the collected solution volume. If within the range of 1.02-2.06 g/hr, the collected volume measurement is confirmed.

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Powertech AMTP05 Salt Fog Test Record DOC. ID: AMFT03-R3		Test Standard: <input type="checkbox"/> ISO 9227:2012 <input checked="" type="checkbox"/> ASTM B117-16
Client/PL#:		Equipment:
Duration:		Asset #:
Start Date/Time:		Cal. Due Date:
End Date/Time:		

Solution Type ¹	Date	Time	Solution Temp (°C)	Specific Gravity ²	pH	Collected Vol (mL)	Mass Check ³ (g/hr)	Elapsed Test Time (hr)	Collection Rate (mL/hr)	Chamber Temp (°C)	Initial
Res.	Aug 23	1:30	25°C	1.03 ^{23.7}	6.48	←					→
⊙ R	Aug 26	18:50 ^{SK}	23.7	1.031 ^{26.5}	6.64	118		56010	1.662	35	SK
⊙ L	Aug 26	18:50 ^{SK}	23.2		6.75	73		56010	1.028	35	SK
Res.	Aug 26		24.1		6.35						
⊙ R	Aug 27	2:10	25.3	1.030	6.27	37.5		56035	1.5	35	SK
⊙ L	Aug 27	2:10	24.9	1.030	6.33	21		56035	0.84	35	SK
Res.	Aug 27	2:20	24.8	1.027	6.95	←					→
⊙ R	Aug 28	2:00	23.3	1.034	6.46	38		56059	1.58	35	SK
⊙ L	Aug 28	2:00	23.1	1.034	6.44	23		56059	0.958	35	SK
Res.	Aug 28	2:30	23.6	1.027	7.77	←					→
⊙ R	Aug 29	2:13	26.2	1.031	6.45	38	0.803	56083		35	9.7
⊙ L	Aug 29	2:13	24.2	1.031 ^{24.4}	6.37	29	0.619	56083		35	14.85
Res.	Aug 29	2:35	24.6	1.026 ^{25.2}	7.62	←					→
L	Aug 30	2:50	24.6	1.032	6.38	25		56106	1.04	35	24
R	Aug 30	2:50	24.6	1.030	6.40	38		56106	1.58	35	24
Res.	Aug 30	2:50	24.4	1.027	7.60	←					→
L	Sep 03	2:50		1.							
R	Sep 03	2:50	28.4	1.032	6.87	130.5		56202	1.35	35	SK
L RES	Sep 03	2:50	28.4	1.032	6.79	104.5	58.22	56202	1.08	35	SK
RES	Sep 03	2:50	25.6	1.030	8.36	←					→
L	Sep 04	2:50	23.4	1.032	6.97	26		56226	1.08	35	SK
R	Sep 04	2:50	23.8	1.032	6.78	42.5		56226	1.77	35	SK
Res.	Sep 04	2:50	25.6	1.030	8.27	←		56226	←	35	SK

Notes:

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Powertech AMTP05 Salt Fog Test Record <small>DOC. ID: AMFT03-R3</small>						Test Standard: <input type="checkbox"/> ISO 9227:2012 <input type="checkbox"/> ASTM B117-16					
Client/PL#:						Equipment:					
Duration:						Asset #:					
Start Date/Time:						Cal. Due Date: 8/0/20					
End Date/Time:											

Solution Type ¹	Date	Time	Solution Temp (°C)	Specific Gravity ²	pH	Collected Vol (mL)	Mass Check ³ (g/hr)	Elapsed Test Time (hr)	Collection Rate (mL/hr)	Chamber Temp (°C)	Initial
R	Sep 05	3:00	26.5	1.032 ^{21.2}	6.44	39		56250		35	SK
L	Sep 05	3:00	26.6	1.032 ^{24.8}	6.63	25		56250		35	SK
Res	Sep 05	3:00		1.028 ^{24.3}	8.08	←					→
R	Sep 06	3:15	22.1	1.031	6.49	28		56273	1.217	35	SK
L	Sep 06	3:15	22.1	1.031	6.48	24		56273	1.043	35	SK
Res	Sep 06	3:15	26.0	1.028	7.99	←					→
R	Sep 09	2:10	27.8	1.030	6.51	127.5	-	56343	1.821	35	SK
L	Sep 09	2:10	27.7	1.031	6.75	75	-	56343	1.071	35	SK
Res	Sep 09	2:10	25.6	1.028	7.72						
R	Sep 10	2:48	25.2	1.032	6.45	28.43		56368	1.72	35	RY
L	Sep 10	2:48	25.1	1.032	6.48	28		56368	1.12	35	RY
RES	Sep 10	2:48	26.4	1.028	6.95	←					→ RY
R	Sep 11	12:06	22.1	1.032	6.53	32		56387	1.684	35	SK
L	Sep 11	12:06	21.6	1.032	6.69	19		56387	1.00	35	SK
RES	Sep 11	12:06	24.0	1.029	7.58	←					→ SK
R	Sep 13	2:40	25.4	1.033	6.68	54		56417	1.542	35	SK
L	Sep 13	2:40	23.9	1.033	6.67	35		56417	1.166	35	SK
RES	Sep 13	2:40	26.0	1.030	8.42	←					SK

Notes:

¹ Solution Type: P = Prepared, R = Reservoir, C = Collected

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³ Report the mass/hour value for the collected solution volume. If within the range of 1.02-2.06 g/hr, the collected volume measurement is confirmed.

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Powertech AMTP05 Salt Fog Test Record <small>DOC. ID: AMFT03-R3</small>		Test Standard: <input type="checkbox"/> ISO 9227:2012 <input type="checkbox"/> ASTM B117-16
Client/PL#:		Equipment:
Duration:		Asset #:
Start Date/Time:		Cal. Due Date:
End Date/Time:		

Solution Type ¹	Date	Time	Solution Temp (°C)	Specific Gravity ²	pH	Collected Vol (mL)	Mass Check ³ (g/hr)	Elapsed Test Time (hr)	Collection Rate (mL/hr)	Chamber Temp (°C)	Initial
R	Sep 16	12:45	26.8	1.032	6.60	137.5		56487	1.964	35	SK
L	"	"	27.2	1.031	7.02	97		56487	1.386	35	SK
RES	"	"	24.1	1.030	8.36	←					→
R	Sep 17	2:25	28.3	1.030	6.50	46		56513	1.769	35	SK
L	"	2:25	24.7	1.030	6.54	30		56513	1.154	35	SK
RES	"	2:25	26.5	1.027	8.20	←					→
R	Sep 18	12:30	28.0	1.031	6.94	37		56534	1.76	35	SK
L	Sep 18	12:30	26.8	1.031	6.82	25		56534	1.19	35	SK
RES	"	12:30	25.2	1.029	7.95	←	→	56534	←		→ SK
R	Sep 19	2:45	25.8	1.033	6.39	53		56561	1.96	35	SK
L	Sep 19	2:45	24.7	1.033	6.48	31		56561	1.15	35	SK
RES	Sep 19	2:45		1.030	7.63	←	→				→
R	Sep 20	1:10	22.7	1.033	6.69	45		56583	2.04	35	SK
L	Sep 20	1:10	22.5	1.033	6.71	25		56583	1.136	35	SK
RES	Sep 20	1:10	24.1	1.030	7.82	←					→ SK
R	Sep 23	1:45	26.7	1.032	6.44	158		56655	2.19	35	SK
L	Sep 23	1:45	25.5	1.030	6.71	83		56655	1.15	35	SK
RES	Sep 23	1:45	24.4	1.030	8.59	←					→
R	Sep 24	11:44	24.0	1.033	6.61	35.5		56677	1.61	35	SK
L	Sep 24	11:44	23.4	1.033	6.57	25		56677	1.14	35	SK
RES	Sep 24	11:44	24.9	1.030	8.30	←					→ SK

Notes:

1 Solution Type: P = Prepared, R = Reservoir, C = Collected

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3 Report the mass/hour value for the collected solution volume. If within the range of 1.02-2.06 g/hr, the collected volume measurement is confirmed.

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