ASSOCIATION OF PLASTIC RECYCLERS

SORTING POTENTIAL TEST METHOD:

Evaluation of the Near Infrared (NIR) Sorting Potential of a Whole Plastic Article

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Introduction

Scope, Significance, and Use

This test is one in the series of "Sorting Potential Test Methods" developed by the Association of Plastics Recyclers (APR).

The sorting potential test methods describe laboratory-scale representations of the most commonly used collection and Material Recovery Facility (MRF) processes for handling single-stream post consumer recyclables. The test methods assume that these co-mingled recyclables are collected curbside, compacted in a typical recycling collection truck, transported to and processed through an automated MRF into bales of similar plastics, then further processed at the plastics reclaimer in their original form before being reduced in size.

These tests do not consider the plastics recycling process starting from or after size reduction at the plastics reclaimer. Nor do they represent other processes that may use different methods of collection and separation with different results. Furthermore, plastic sorting processes have some degree of variability in commercial practice. It is not the intent of this protocol to model every possible process outcome but to choose a common set of parameters widely employed and which fall squarely within those used in industry.

The sorting potential tests are intended to identify specific design features that may cause an entire package to be lost in the recycling process. The consequences of a plastic article being mis-sorted prior to size reduction are more significant than in processes that follow size reduction, since the entire package is lost to the plastics recycling stream rather than a mere component of the package. The modeling of sorting behavior in this test enables design engineers to focus their improvement efforts and is designed to complement the wide range of tests offered by APR that form the foundation of APR's Design Guidance for plastic package recyclability.

Typically, today's newer single stream MRFs and PET reclaimers employ automated equipment that sort plastic packaging and other items by their NIR (near infrared) signature, either in transmission or reflection. For this equipment to operate effectively it must accurately identify the plastic article and direct it to the correct location. Otherwise, the article is either directed to the waste stream or becomes a contaminant in another recyclable stream where it is likely to not be recycled.

This specific NIR sorting potential test method provides a means of evaluating whether a plastic article can be accurately identified and sorted on pilot scale NIR sortation equipment that performs similarly to that used in production facilities. Good results in this screening test indicate that a plastic article has the potential to be sorted well in production conditions. Poor results indicate that an improvement in plastic product design is desirable to promote recovery. An optional, second part of this test method incorporates a means of determining whether the pilot equipment & software has the ability to be

adjusted to correctly identify and sort this article and if so, to capture this adjustment in production facilities.

The test involves establishing the baseline performance of a pilot NIR sorting machine by processing a known blend of material while targeting the polymer of the test article. Then, 20 samples of the test article are added and the mix is reprocessed. Sorting efficiency of the test articles is compared to the baseline efficiency. Five passes through the NIR unit are used to develop repeat values for the test articles.

Reference Documents

- Compression Practice
  APR-SORT-P-00 Practice Compressing Plastic Articles for Laboratory Evaluation
- APR Recommended Testing Facilities
  https://plasticsrecycling.org/apr-design-hub/testing-protocols-labs/apr-recommended-testing-facilities/

Test/Method Summary and Flow Diagram

The flow diagram below outlines the test process. First, the baseline sorting efficiency for the polymer in question is established by running a mix of known items through the NIR sorter and recording the sortation results. Then, 20 of the candidate articles are added to the mix and it is processed through the NIR sorter. This is repeated five times. The results of the baseline sorting efficiency and the candidate article sorting efficiency are then compared.

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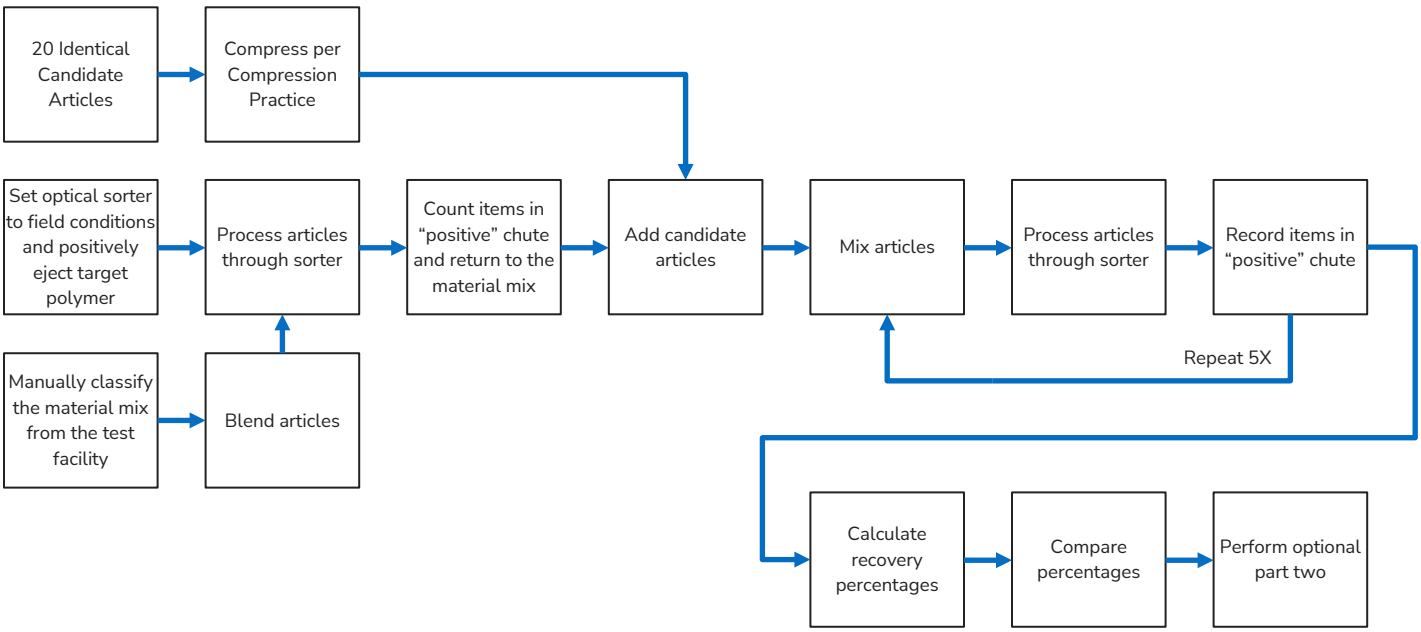


Equipment Required

1. Bottle compression device built per the instructions found at APR-SORT-P-00 Practice Compressing Plastic Articles for Laboratory Evaluation
2. Binary NIR bottle sorter operating in representative (reflective or transmissive) mode of typical field equipment, with applicable feed belt and discharge chutes. This test is conducted on pilot plant scale NIR sortation equipment. Please refer to APR Recommended Testing Facilities for a list of potential testing facilities: https://plasticsrecycling.org/apr-design-hub/testing-protocols-labs/apr-recommended-testing-facilities/

These businesses each maintain and operate pilot scale sorting equipment. There may be a service fee for pilot evaluations.

Materials Required

1. 20 identical candidate test articles provided by the test applicant. These articles should be fully decorated, i.e. with label, closures, etc. as if they were placed in a curbside bin after consumer use. Note that these articles are empty whereas some residual product may remain in the articles found in the actual recycling stream. Sorting machines are generally programmed to minimize the effects of common amounts of residual product so this test does not consider residual product.
2. Mix of plastic articles representing the plastic material commonly processed through a container line at a MRF. This mix should be of sufficient quantity to operate the trial sorting machine at 50% nameplate throughput or greater for at least 1 minute (a general rule of thumb for nameplate capacity is 1 ton/hr per meter of machine width which equates to 34 lbs per minute or approximately 733 bottles per minute but this ratio is dependent on manufacturer). These articles are normally provided and maintained by the test lab, should be previously compressed through the actual collection system and include labels and attachments. By weight percent the mix should consist of:

- 7-12% Polypropylene containers between 8 oz. and 2 liters
- 12-17% HDPE natural containers between 8 oz. and 1 gallon
- 16-21% HDPE colored containers between 8 oz. and 1 gallon
- 45-50% PET containers between 8 oz. and 2 liters, insuring that at least 20 of the following are represented:
    - clear or light blue single serve water
    - clear 2 liter carbonated soft drink
    - green 2 liter carbonated soft drink
    - clear with shrink sleeve label less than 75% label coverage
- 2-3% PETG containers
- 10-15% Other plastic containers, insuring that PS, PVC and black items are represented.

Method Steps

1. Take pictures of all articles for submission including:
    a. One candidate test article before compression
    b. All candidate test articles after compression (one collective picture)
    c. The mix of other articles (one collective picture)

2. Compress the candidate articles according to the APR compression practice found at: APR-SORT-P-00 Practice Compressing Plastic Articles for Laboratory Evaluation

    Note: This is an extremely important step since compression helps flatten the articles, making them less likely to slide on the conveyor belt. Successful optical sorting requires articles to remain stable on the conveyor belt so the ejector can be timed with the sensor. Sorting tests performed on rounded items that are not compressed may have poor results.

3. Collect and classify the material mix (it is anticipated that the testing lab maintains this mix in its facility for use as required and the classification has already been completed):
    a. Complete the attached form classifying the mix with the weight and count of each article type.
    b. Insure the mix is of sufficient size to feed the sorter at 50% rated throughput or greater for at least 1 minute. It is permissible and expected to adjust the usable width of the sorter to fall within these parameters.

4. Establish the baseline:
    a. Set ALL sorter parameters to represent the typical machines installed in the field.
    b. For a candidate article primarily made from PET these parameters should represent the settings at a PET reclaimer since these machines typically represent the most stringent criteria in the process.
    c. For a candidate article primarily made from PP or HDPE these parameters should represent the settings at a MRF since they are typically the only automatic sorters in the recycling process.
    d. Using the manufacturers operating procedure, set the sorter to positively sort the polymer which represents the candidate article. DO NOT USE THE TEST ARTICLE TO ADJUST THE SETTINGS. Note: The purpose of this test is to represent the performance of the machines in the field, not the capabilities of the latest machine version. Therefore, this test is not an appropriate brand-to-brand or machine-to-machine comparison.
    e. Blend the material mix without the candidate articles in a container so they are randomly mixed.
    f. Meter the mixed articles onto the accelerating belt (or vibratory feeder – depending on test facility) at a rate

at least 50% of the sorters nameplate throughput.

g. Record the number and percent of the target polymer articles correctly/ positively sorted on the form below.

5. Test the candidate article.
    a. To the material mix, reintroduce the items positively sorted from the baseline sort.
    b. Add the candidate articles to the material mix and blend in a container so they are randomly mixed.
    c. Meter the mixed articles onto the accelerating belt (or vibratory feeder – depending on test facility) at a rate at least 50% of the sorters nameplate throughput.
    d. Record the number of candidate articles positively sorted on the form below.
    e. Repeat 5 times.

Measurements

For each run, record the count of the "positively" ejected test articles per the report form.

Report Form

Found in Annex 1

Assessment

Variance = The difference between the sorting efficiency of the test polymer established in the baseline test, minus the sorting efficiency of the test article in aggregate of the following tests (see calculations in the report form and example).

Capture rate = The percentage of test articles correctly sorted in the aggregate of the tests. (see calculations in the report form and example).

If Variance is < =5%: The candidate article is most likely to be sorted correctly by NIR and the APR Design Guidance category for the design feature of "optical sorting potential" is **APR Design® Preferred**.

If Variance is >5% and Capture rate is >=51% A high percentage of the test articles will be missorted by NIR, but will most likely get sorted into the appropriate bale. The APR Design Guidance category for the design feature "optical sorting potential" is **Detrimental to Recycling**.

If Capture rate % is < 51%: The candidate article will most likely be missorted by NIR and therefore the APR Design Guidance category for the design feature "optical sorting potential" is **Renders Package Non-Recyclable** per the APR definition of recyclability.

Optional, Part Two

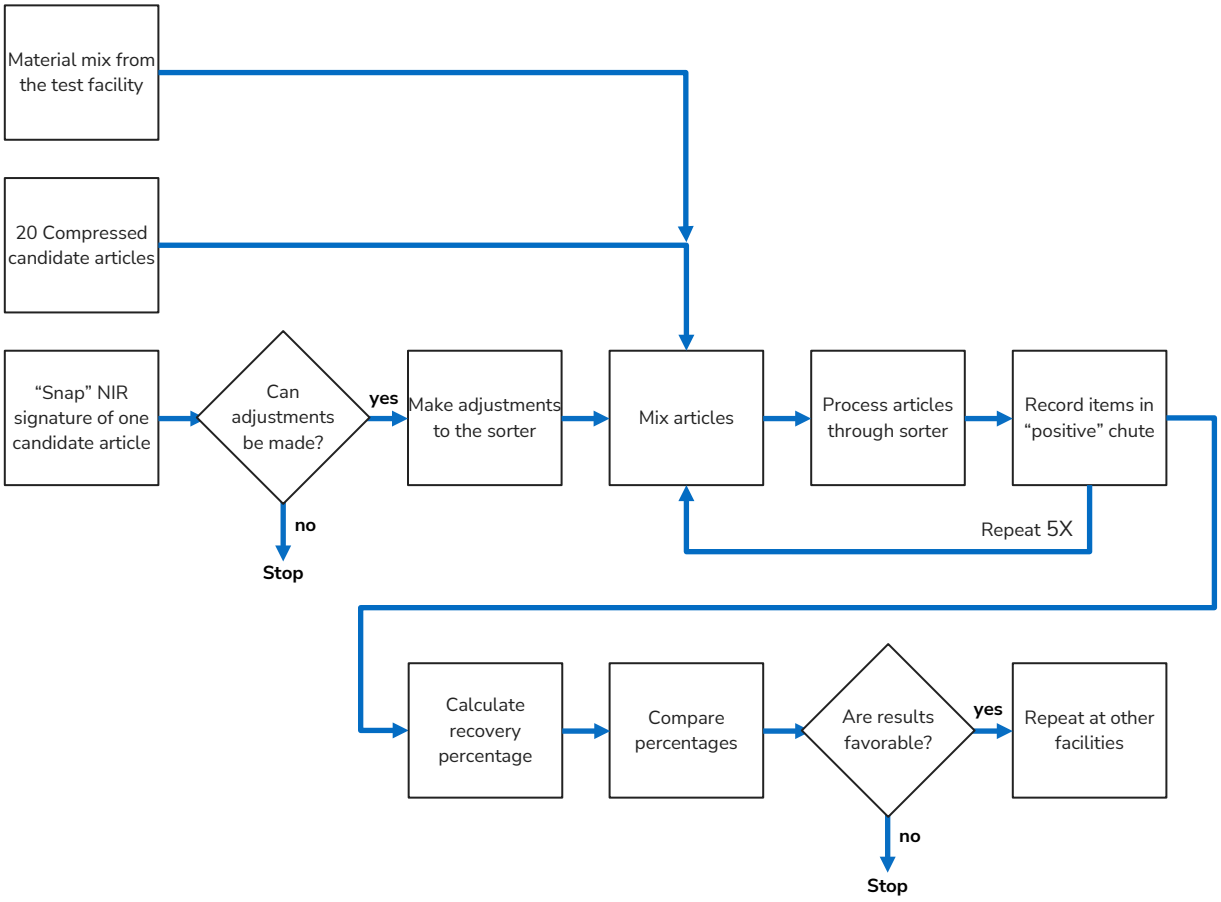
Introduction

Scope, significance and use

It is possible that a candidate article doesn't perform well in the test described above, not due to the machine capabilities, but the programming. This may be the case when new materials are introduced into the plastics recycling stream. It is not APR's intent to stifle innovation that may be otherwise beneficial to the plastics recycling industry and as such, offers a method for these items to be integrated into it. The second part of this test evaluates the sorting machines capability of sorting these types of test articles and if applicable, to encourage industry-wide software updates to capture them. Since the predominant installed equipment base must be capable of correctly sorting these articles the test must be repeated at other test facilities to prove the concept.

Test/Method Summary and Flow Diagram

This test method involves adjusting the sorter to the candidate article and rerunning the test described above.



Method Steps

1. Snap the NIR Signature of the Candidate Article:
    a. Using the method appropriate to the specific sorter, place one candidate article at a time under the sensor and take a snap shot of the article.
    b. If possible, adjust the sorter to incorporate that profile into the correct polymer classification.

2. If the sorter was capable of identifying the test article, test the candidate article using the adjusted machine.
    a. Add the candidate articles to the material mix and blend in a container so they are randomly mixed.
    b. Meter the mixed articles onto the accelerating belt (or vibratory feeder – depending on test facility) at a rate at least 50% of the sorters nameplate throughput.
    c. Record the number of candidate articles positively sorted on the form below.
    d. Repeat 5 times.

3. Given positive results with the adjustments (variation <5% from the baseline) the applicant must then perform the test at all the test facilities listed so that the adjustments can be implemented throughout the majority of the industry. One report per equipment manufacturer should be used in this case.

Measurements

For each run, record the count of the "positively" ejected test articles per the report form below

Report Form

Found in Annex 3.

Assessment

If, at least three of the 4 facilities:

Variance is <5%: Current NIR sorting machinery has the ability to sort the candidate article correctly if adjusted but the installed machinery base has not been adjusted to do so. Through this test protocol sorting companies are aware of these adjustments and can implement them in the field. The APR is optimistic that the adjustments are implemented in the installed machinery base so that APR Design Guidance category for the design feature of "optical sorting potential" is **APR Design® Preferred** in the future.

Variance is >5% and Capture rate is >=51%: Current NIR sorting machinery has the ability to meet the basic standards of recoverability if adjusted but a high percentage will be missorted by NIR. The installed machinery base has not been adjusted to sort the candidate article. Through this test protocol sorting companies are aware of these adjustments and can implement them in the field. The APR is optimistic that the adjustments are implemented in the installed machinery base so that APR Design Guidance category for the design feature of "optical sorting potential" is **Detrimental to Recycling** in the future.

Capture rate % is < 51%: The candidate article will most likely be missorted by NIR now and in the near future and therefore the APR Design Guidance category for the design feature "optical sorting potential" is **Renders Package Non-Recyclable** per the APR definition of recyclability.

Annexes

1. **Report form: Near Infrared Sorting Potential of a Whole Plastic Article**
2. **Sample completed report form and calculations**
3. **Part 2 report form: Near Infrared Sorting Potential of a Whole Plastic Article, Sorter Capability**

Table and Figures

None

Annex 1: Report Form

NEAR INFRARED SORTING POTENTIAL OF A WHOLE PLASTIC ARTICLE
Record Sheet – APR Test

Background		
Testing Facility		
Testing Facility Technician		
Date		
Candidate Article Description	*Volume*	
	Color	
	Label Material	
	Closure Material	
	Body Material	(target polymer)
	Brand/Description	

Machinery	
Nameplate Throughput for the Width Used (lbs/hr)	
Weight of Material Required for 50% Rated Throughput for 1 Minute	

Material Mix

Material	Target % by weight	Actual weight	Count
PP containers	7-12%		
HDPE Natural Containers	12-17%		
HDPE Colored Containers	16-21%		
PET Containers	45-50%		
PETG Containers	2-3%		
Other Plastic Containers	10-15%		
	Total		
			% of material required for 1 min. run

Baseline Test

Target Polymer name _____

# of target polymer items ejected _____

% of target polymer items ejected _____

Candidate Article Tests

	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6
# of test articles ejected						
% of test articles ejected						
						Capture Rate

Variance Calculation

(% of target polymer items ejected [from Baseline Test]) –
(total % of test articles ejected [from Candidate Article Tests])= Variance _____

Assessment

Variance	Capture Rate	Applicable APR Recyclability Category for "NIR Sorting Potential" (see category descriptions in APR Design® Guide for Plastics Recyclability Homepage	Check Applicable Box
< - 5%	> - 51%	APR Design® Preferred	
> 5%	> - 51%	Detrimental to Recycling	
n/a	< 51%	Renders Package Non-Recyclable per APR definition	

Testing Facility Technician Signature _____

Comments

What features cause negative results?, What could be done to improve sorting?, etc.

These results are not to be misinterpreted or misused to judge the performance of individual macine manufacturers.

Annex 2: Sample Completed Form and Calculations

Annex 1: Report Form

NEAR INFRARED SORTING POTENTIAL OF A WHOLE PLASTIC ARTICLE
Record Sheet - APR Test #

BACKGROUND

TESTING FACILITY		Acme Testing Lab
TESTING FACILITY TECHNICIAN		Wiley Coyote
DATE		November 25, 2017
CANDIDATE ARTICLE DESCRIPTION	Volume	500 ml
	Color	clear
	Label Material	PP
	Closure material	HDPE
	Body material	PET (target polymer)
	Brand/Description	XX Water

MACHINERY

NAMEPLATE THROUGHPUT FOR THE WIDTH USED -lbs/hr: 2000

WEIGHT OF MATERIAL REQUIRED FOR 50% RATED THROUGHPUT FOR 1 MINUTE: - lbs: (2000÷60×.5)= 17

MATERIAL MIX

Material	Target % by weight	Actual weight	Count
PP containers	7-12%	2.16	45
HDPE Natural containers	12-17%	2.88	57
HDPE Colored containers	16-21%	4.32	86
PET Containers	45-50%	10.80	216
PETG Containers	2-3%	0.48	9
Other Plastic Containers	10-15%	3.36	67
	Total	24.0	
		141%	% Of material required for 1 minute run

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BASELINE TEST

Target Polymer name: PET

# of target polymer items ejected: 203 (measured)

% of target polymer items ejected: 203/216 ← from material mix = 94%

CANDIDATE ARTICLE TESTS

	RUN 1	RUN 2	RUN 3	RUN 4	RUN 5	TOTAL
# of test articles ejected	18	16	18	18	20	90
% of test articles ejected	90%	80%	90%	90%	100%	90% Capture rate

VARIANCE CALCULATION

% of target polymer items ejected (from baseline test) - total % of test articles ejected (from candidate article tests) =

94% - 90% = variance 4%

ASSESSMENT

Variance	*Capture Rate*	*Applicable APR Recyclability Category for "NIR Sorting Potential" (see category definitions In APR Design Guide for Plastics Recyclability Home Page)*	*Check Applicable Box*
< = 5%	> = 51%	APR Design Guide Preferred	✓
> 5%	> = 51%	Detrimental to Recycling	
n/a	< 51%	Renders Package non-Recyclable per APR Definition	

Testing Facility Technician Signature: Wiley Coyote

Comments: What features cause negative results?, What could be done to improve sorting? etc.

Annex 3: Part 2 Report Form *(one form per test facility)*

NEAR INFRARED SORTING POTENTIAL OF A WHOLE PLASTIC ARTICLE
Record Sheet – APR Test

Background

Testing Facility		
Testing Facility Technician		
Date		
Candidate Article Description	*Volume*	
	Color	
	Label Material	
	Colsure Material	
	Body Material	(target polymer)
	Brand/Description	

Machinery

Nameplate Throughput for the Width Used (lbs/hr)	
Weight of Material Required for 50% Rated Throughput for 1 Minute	

Material Mix

Material	Target % by weight	Actual weight	Count
PP containers	7-12%		
HDPE Natural Containers	12-17%		
HDPE Colored Containers	16-21%		
PET Containers	45-50%		
PETG Containers	2-3%		
Other Plastic Containers	10-15%		
	Total		
			% of material required for 1 min. run

Baseline Test

Target Polymer name	
# of target polymer items ejected	
% of target polymer items ejected	

Candidate Article Tests

	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6
# of test articles ejected						
% of test articles ejected						
						Capture Rate

Variance Calculation

(% of target polymer items ejected [from Baseline Test]) –
(total % of test articles ejected [from Candidate Article Tests])= Variance _____

Assessment

Variance	Capture Rate	Applicable APR Recyclability Category for "NIR Sorting Potential" (see category descriptions in APR Design® Guide for Plastics Recyclability Homepage	Check Applicable Box
< - 5%	> - 51%	APR Design® Preferred	
> 5%	> - 51%	Detrimental to Recycling	
n/a	< 51%	Renders Package Non-Recyclable per APR definition	

Testing Facility Technician Signature _____

Comments

What features cause negative results?, What could be done to improve sorting?, etc.

Sorting Equipment Manufacturer Statement *(if part 2 of the test was performed successfully)*

Although our typical NIR sorting machinery installed in MRFs and PET reclaimers is not currently adjusted to correctly sort the candidate article, our machinery has the capability of being adjusted to do so. Our company is aware that the candidate article may be introduced into the curbside recycling stream and will add the adjustments to new machines and software/hardware updates in order that the candidate article may be recovered by our sorters in the future.

Signature _____

Company _____

Disclaimer

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Document Version History

Version	*Publication Date*	*Changes Made*
1	December 11, 2017	
2	May 15, 2018	
3	August 30, 2024	Change to Naming Convention (B) to (S) to match Single Purpose Test; Changed hyperlinks to new website