MONTHLY PROGRESS REPORT
Slurry/Micro-Surface Mix Design Procedure
November 2004

To:	**T. Joe Holland, CALTRANS**
Contract No.:	**CALTRANS 65A0151**
Contractor:	**Fugro Consultants LP**
Contract Period:	**June 30, 2003 – Nov. 30, 2007**
Prepared By:	**Jim Moulthrop, Principal Investigator**
Date Prepared:	**December 15, 2004**

PROJECT OVERVIEW

The overall goal of this research is to improve the performance of slurry seal and micro-surfacing systems through the development of a rational mix design procedure, guidelines, and specifications.

Phase I of the project has two major components: 1) the first consists of a literature review and a survey of industry/agencies using slurry and micro-surfacing systems, 2) the second deals with the development of a detailed work plan for Phases II and III.

In Phase II, the project team will evaluate existing and potential new test methods, evaluate successful constructability indicators, conduct ruggedness tests on recommended equipment and procedures, and prepare a report that summarizes all the activities undertaken under the task.

In Phase III, the project team will develop guidelines and specifications, a training program, and provide expertise and oversight in the construction of pilot projects intended to validate the recommended design procedures and guidelines. All activities of the study will be documented in a Final Report.

NOTE: New information for the current month is notated by double-lines to the left of text, tables, or figures.

PHASE I—LITERATURE SEARCH AND WORK PLAN DEVELOPMENT

Task 1 Literature Review and Industry Survey—Completed

The literature review process is completed with all sources of information on the design and use of micro-surfacing and slurry seals reviewed and summarized in Chapter 2 of the Phase I Report. The three survey questionnaires were included in the August 2003 monthly report and the results were summarized in the Phase I Report.

Task 2 Work Plans for Phases II and III—Completed

The Phase II Work Plan was included in Chapter 3 of the Phase I Report. The Phase III Work Plan was included in Chapter 4 of the Phase I Report.

All activities of Phase I are completed. The results are included in the Phase I Interim Report that was submitted to CALTRANS in March 2004.

PHASE II—MIX DESIGN PROCEDURE DEVELOPMENT

Tasks 3 & 4—Evaluation of Potential Test Methods & Successful Constructability Indicators

The team is working towards the acquisition of the new test equipment to be used in Phase II. The equipment includes:

Visco-Time®: An apparatus that will measure the rotational viscosity of a slurry system with time. The results will be used to evaluate the time available for mixing and spreading the mixture in the field and an estimate of the set time.

Two similar devices are available from Europe: Viscoclick and Eurostar. The difference between these two devices is in the method of measuring the rotational torque: Viscoclick measures the torque acting on the mixing shaft while Eurostar measures the torque acting on the motor that rotates the mixing shaft. Viscoclick is potentially more accurate, but also more expensive. A preliminary evaluation and comparison of the two devices will be carried out as soon as the equipment becomes available.

Although arrangements were made to loan the equipment from IKA, for various reasons delivery was repeatedly delayed and the equipment is still not available. The team made arrangements with another contractor, Valley Slurry Seal to purchase the equipment and this way ensure delivery by January 1st.

French Wet Track Abrasion Test (FWTAT) Device: An apparatus that is very similar to the Wet Track Abrasion Test (WTAT), but uses a set of wheels instead of the rubber hose normally used for the abrasion head. The apparatus has been modified to use the French Wheel fixture and is going through refinements.

As reported last month, the shaft for the device was not the proper size and it has been modified. This equipment is in the laboratory at Consolidated Engineering Laboratories, and is ready to begin testing.

Modified Cohesion Tester: An automated modified cohesion tester (i.e., the torque will be applied by means of an automated device instead of a manual method). The team is in the process of modifying the device to make it automated.

The equipment is in its final phase of manufacture, whereby it is being tested with dummy samples to work out the bugs in the programming.

Specimen Preparation Molds: It is the intention of the research team to test mixtures in the laboratory, as they will be delivered to the field. The current ISSA TB 100 procedure (WTAT) requires the coarser materials to be scalped from the aggregate before mix samples are prepared for the test. The entire mixture gradation will be used and will require the fabrication of specimen molds to accommodate the coarser aggregate. A local machine shop in Oakland, CA, will fabricate the metal and acrylic molds.

Environmental Chamber: Many of the tests of Phase II will be performed under controlled temperature and humidity conditions that require the use of one or several environmental chambers. These are already available in the CEL laboratories where most of the testing will be performed.

The matrix of tests to be performed in Task 3 is being reviewed by the team; a range of conditions will be used in the test program:

- Humidity: High and Low
- Temperature: 10, 25 and 30°C (50, 77 and 86°F)
- Cure time: 30, 60, 90 Minutes; 12 and 24 Hours
- Soak time: 1hour; 1,3,6 and 9 Days

Tentatively, five mixes are planned for inclusion in the test program. Four will be made of aggregates and binders known to perform well in slurry systems, and one will be made of materials for which the performance is unknown. The five mixes are:

- Mix 1 Ralumac + Table Mountain Aggregate (supplied by Koch)
- Mix 2 Ralumac + Lopke Gravel Aggregate (Koch formulation for emulsion)
- Mix 3 VSS PMCQS-1h + Table Mountain Aggregate
- Mix 4 Vestal PM CQS -1h + Lopke Gravel Aggregate
- Mix 5 Unknown

Testing of the Table Mountain and Lopke Gravel Aggregates is complete. Tests included sieve analysis, sand equivalent, Los Angeles abrasion, and sodium sulfate soundness testing. The results were noted in previous progress reports. The aggregates have been forwarded to Valley Slurry Seal and Koch Materials for the formulation of the emulsions.

The sodium sulfate testing had been re-done because an old solution was used for the initial testing and there is some concern that the results might not be valid. The results were included in Attachment A of the August 2004 progress report.

The standard suite of ISSA mix design tests was performed on both mixtures to establish "benchmarks" before progressing to the new and modified test procedures. The results are included in Appendix A of this progress report.

Task 5—Ruggedness Tests of Recommended Equipment and Procedures

In comparison with the testing in Tasks 3 and 4, the tests of Task 5 will be performed at a single set of temperature, humidity, and cure time conditions. "Standard" conditions were chosen by the team (e.g., 50 percent humidity, 25°C temperature). Slight variations in these parameters will be allowed to evaluate the ruggedness of the test procedures. The team is currently reviewing the test factorials proposed in the Phase II Work Plan.

Task 6—Phase II Report

No Activity

PHASE III— PILOT PROJECTS AND IMPLEMENTATION

Task 7—Development of Guidelines and Specifications

A list of references that contain guidelines and specifications has been drafted and is noted below:

- ISSA A105 Guidelines for Slurry—Available
- ISSA A143 Guidelines for Micro-Surfacing—Available
- TTI Report 1289-2F Use of Micro-Surfacing in Highway Pavements—Available.
  Report contains:
  - Methods and Materials Specifications
  - Quality Control and Assurance Tests (including field cohesion and vane shear tests)
  - Quality Control Guidelines (including materials acceptance tests and mixture design verification)
  - A Checklist
  - Usage Guidelines.
- ISSA Inspector's Manual—Available
- Caltrans Maintenance Technical Advisory Guide Final Draft—Available
- The ISSA Workshop Folder—Available

The guidelines and specifications will be a concise collection, presented in AASHTO format. This is one area of Phase III where the team can work at present. At the end of Phase II, the document will be appended with findings and recommendations relative to the new tests developed in Phase II.

Task 8—Workshop Training Program/Pre-Construction Module

The team agreed that work could commence in several chapters of the Reference Manual to be developed under this task. The Reference Manual will be a comprehensive, textbook-like document with background information, explanations, and pertinent information on the design and use of slurry systems.

A template for the Reference Manual has been produced and work has begun on the development. A draft outline of the Manual is presented here:

- Chapter 1. Introduction
  - Historical Developments
  - Why Slurry Systems
  - The Future of Slurry Systems
  - Objectives of the Manual
  - Organization of Material
- Chapter 2. Slurry Systems Review
  - What is Slurry Seal
  - What is Micro-Surfacing
  - Slurry Systems

- Chapter 3. Project Selection Criteria
- Chapter 4. Mix Design
    - Mix Design Flowchart
    - Binder Requirements
    - Aggregate Requirements
    - Blending Requirements
    - Test Methods
    - Mix Design Examples
- Chapter 5. SyRaMiD Specifications
- Chapter 6. Construction Considerations and Limitations
    - Project Geometry
    - Weather Limitations
- Chapter 7. Construction Operations
    - Equipment and Calibration Requirements
    - Surface Preparation
    - Workmanship Requirements
    - Stockpile Management
    - Mix Design Verification
    - Troubleshooting
- Chapter 8. Quality Control
- References
- Appendices
    - Test Protocols
- Glossary

Task 9—Pilot Projects/Procedure Validation

The team is working on the development of guidelines for selecting pilot projects to be used by State agencies. Currently, the proposed pilot project layout contains six different sections:

- A control section placed using the ISSA current procedure.
- A bare section (do nothing)
- Improved mix design (using the method developed in Phase II), Replicate 1
- Another contractor-based control (ISSA design).
- Another bare section.
- Improved mix design (using the method developed in Phase II), Replicate 2

The final version of the Guidance Document was included in Appendix A of the October 2004 progress report. The document was forwarded to the participant State agencies and other agencies interested in participating in the pilot project study.

Task 10—Final Report

No Activity

NEXT MONTH'S WORK PLAN

The activities planned for next month are listed below.

- Coordinate with CALTRANS personnel on an as-needed basis.
- Continue with Phase II and Phase III activities.

PROBLEMS / RECOMMENDED SOLUTIONS

Despite all efforts, there are still problems with the acquisition of the test equipment. This may cause a delay with the planned testing schedule. The team will make every effort to expedite the work when the equipment is received. However, all other project activities will follow the initial schedule.

APPENDIX A

ISSA MIX DESIGNS

Prepared For: Fugro Date:11/30/04
Subject: Mix Design per ISSA A105/A143 CEL#:10-17749
Aggregate: Lopke 2A
Emulsion: Koch MK4

Wet Track Abrasion Test per ISSA TB100

	% Emulsion							
	9A	9B	11A	11B	13A	13B	15A	15B
Original Wt, grams	775.8	766.2	757.5	791.7	736.8	740.9		
Final Wt, grams	542.7	581.0	732.6	722.9	715.8	722.3		
grams of abrasion loss	233.1	185.2	24.9	68.8	21.0	18.6	#VALUE!	#VALUE!
g/sqft Loss (3.06 factor)	713.3	566.7	76.2	210.5	64.3	56.9	#VALUE!	#VALUE!
Average Loss, g/sqft	**640.0**		**143.4**		**60.6**		**In progress**	

Trial Mix Procedure per ISSA TB113

Trial#	Temp °C	Cement %	Dist.Water %	Additive %	Emulsion %	Break Time, min	Comments
1	25	0.0	6.0	0.0	10.0	n/a	too dry
2	25	0.0	10.0	0.0	10.0	0:01	immediate break
3	25	0.0	10.0	0.5	10.0	0:05	adjustment to additive needed
4	25	0.0	12.0	1.0	10.0	0:15	adjustment to additive needed
5	25	1.7	12.0	1.0	10.0	2:25	thick mix; slow break at end
6	25	0.5	12.0	1.0	10.0	2:30	creamy mix; slow break at end
7	25	1.0	10.0	0.0	11.0	0:30	needs liquid additive

Additional comments: Cement: Portland, Type 2 Additive: emulsifier dilute
Result: Trial 6 will be the baseline for developing mix results/optimization.

Wet Stripping Test for Cured Slurry Seal per ISSA TB114

Trial#	Temp °C	Cement %	Dist.Water %	Additive %	Emulsion %	Retained Coating	Comments
6	25	0.5	12.0	1.0	10.0	95%	

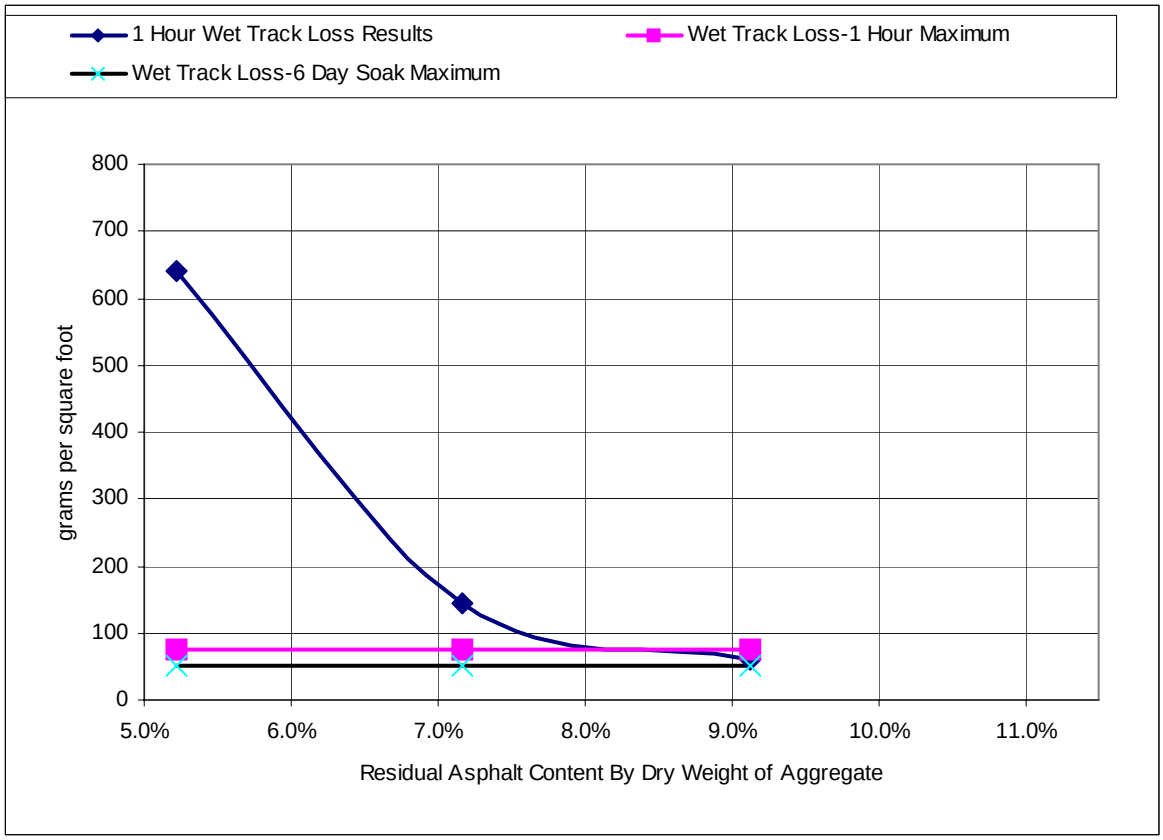
Reference
:__90% retained coating satisfactory
__75% to 90% retained coating is marginal
__below 75% retained coating is unsatisfactory

Prepared For: Fugro Date:11/30/04
Subject: Mix Design per ISSA A105/A143 CEL#:10-17749
Aggregate: Lopke 2A
Emulsion: Koch MK4

Preliminary ASPHALT OPTIMIZATION RESULTS

Residue By Evaporation, CTM 331: 65.2%

Trial #	Emulsion Content	Asphalt Content	Wet Track 1 Hr Loss g-sqft	ISSA SPEC A105 1 Hr Loss Max. g-sqft	ISSA SPEC A143 1 Hr Loss Max. g-sqft
1	8.0%	5.2%	640	75	50
2	11.0%	7.2%	143	75	50
3	14.0%	9.1%	61	75	50
4	17.0%	11.1%	In Progress	75	50

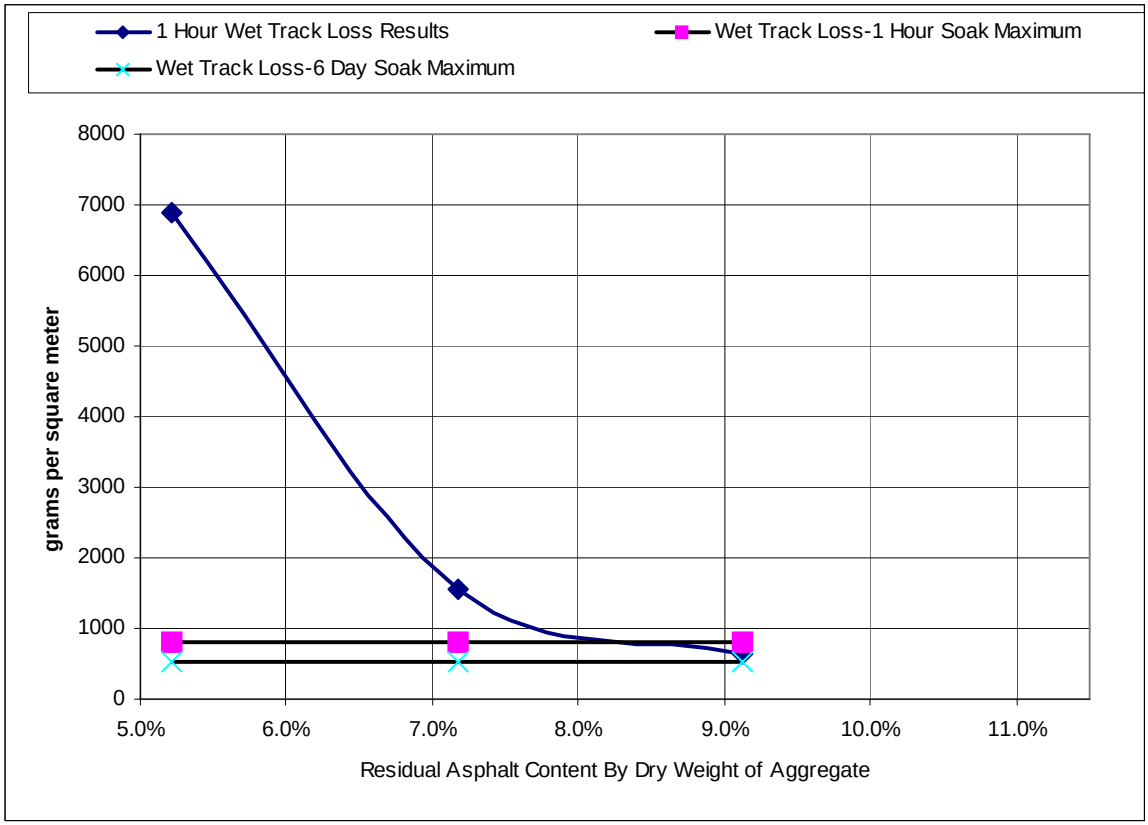


Prepared For: Fugro — Date:11/30/04
Subject: Mix Design per ISSA A105/A143 — CEL#:10-17749
Aggregate: Lopke dA
Emulsion: Koch MK4

Preliminary ASPHALT OPTIMIZATION RESULTS

Residue By Evaporation, CTM 331: 65.2%

Trial #	Emulsion Content	Asphalt Content	Wet Track 1 Hr Loss g-sqm	ISSA SPEC Spec 1 Hr Loss Max. g-sqm	ISSA SPEC Spec Adhesion Max. g-sqm
1	8.0%	5.2%	6886	807	538
2	11.0%	7.2%	1543	807	538
3	14.0%	9.1%	652	807	538
4	17.0%	11.1%	In Progress	807	538



Prepared For: Fugro Date:11/30/04
Subject: Mix Design per ISSA A105/A143 CEL#:10-17749
Aggregate: Table B1
Emulsion: Koch MK3

Wet Track Abrasion Test per ISSA TB100

	% Emulsion							
	9A	9B	11A	11B	13A	13B	15A	15B
Original Wt, grams	720.7	717.7	706.5	680.0	646.7	675.5		
Final Wt, grams	702.1	696.9	690.6	669.2	638.6	668.2		
grams of abrasion loss	18.6	20.8	15.9	10.8	8.1	7.3	#VALUE!	#VALUE!
g/sqft Loss (3.06 factor)	56.9	63.6	48.7	33.0	24.8	22.3	#VALUE!	#VALUE!
Average Loss, g/sqft	**60.3**		**40.9**		**23.6**		**In progress**	

Trial Mix Procedure per ISSA TB113

Trial#	Temp °C	Cement %	Dist.Water %	Additive %	Emulsion %	Break Time, min	Comments
1	25	0.0	12.0	0.0	10.0	0:15	quick break
2	25	0.0	13.0	1.0	10.0	1:05	bubbles initially; extra liquids; medium texture before break
3	25	0.5	12.0	1.0	10.0	5:05	extra liquids up to 3 min; segregation; crumbly coarse in mix; no froth
4	25	1.0	10.0	1.0	10.0	3:30	extra liquids up to 2.5 min; no froth
5	25	1.0	8.0	1.0	11.0	3-5	extra liquids up to 2.5 min; no froth
6	25	1.0	8.0	0.0	11.0	3:37	more even mix; flows more homogenously; slight bubbles

Additional comments: Cement: Portland, Type 2 Additive: emulsifier dilute
Aggregate appears to be turning black very quickly, although the mix remains flowing (very reactive rock?).
Ammonia gas/smell is a result of at least 5 seconds of mixing.
Result: Trial 6 will be the baseline for developing mix results/optimization.

Wet Stripping Test for Cured Slurry Seal per ISSA TB114

Trial#	Temp °C	Cement %	Dist.Water %	Additive %	Emulsion %	Retained Coating	Comments
4	25	1.0	10.0	1.0	10.0	100%	
6	25	0.0	13.0	1.0	10.0	100%	

Reference: __90% retained coating satisfactory
__75% to 90% retained coating is marginal
__below 75% retained coating is unsatisfactory

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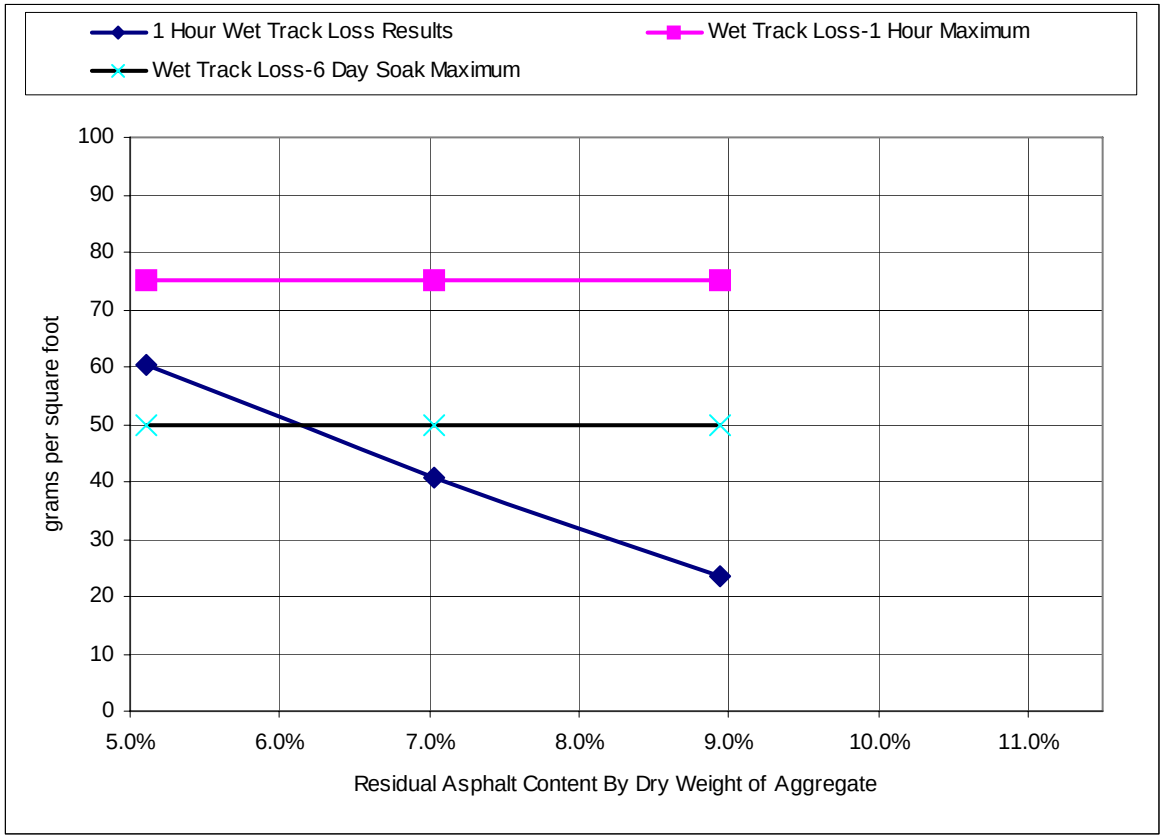
Trial #	Emulsion Content	Asphalt Content	Wet Track 1 Hr Loss g-sqft	ISSA SPEC A105 1 Hr Loss Max. g-sqft	ISSA SPEC A143 1 Hr Loss Max. g-sqft
1	8.0%	5.1%	60	75	50
2	11.0%	7.0%	41	75	50
3	14.0%	8.9%	24	75	50
4	17.0%	10.9%	In Progress	75	50



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1	8.0%	5.1%	649	807	538
2	11.0%	7.0%	440	807	538
3	14.0%	8.9%	254	807	538
4	17.0%	0.109	In Progress	807	538