# Implementation of the Surface Performance-Grade (SPG) Specification for Chip Seal Binders in Texas

*TxDOT Implementation Project 5-6616*

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## OUTLINE

- Motivation & Objective
- Evolution of SPG
- Validation of SPG
- 2016 SPG Specification
- SPG Binder Selection
- Current Validation
- Industry Interaction
- 2017 SPG Specification
- Effects & Challenges of SPG
- Next Steps

## MOTIVATION & OBJECTIVE

- Increase performance and reduce cost
- Improve chip seal/seal coat binder spec & selection
  - performance-related tests
  - @ temperatures that cover entire ***in service*** range for specific climate
  - consider aging during critical 1st year
  - reduce variability in grades
  - possibly adjust due to traffic
- Implement SPG in TX in multi-year, staged effort
  - Replace Seal Coat Binder Tier Selection Table & Item 300 Seal Coat Binder Properties ***in service***

| | AC-15P | AC-10-2TR | AC-20-5TR | SPG |
|---|---|---|---|---|
| **Composition** | | | | |
| Polymer Required? | X | X | X | |
| Min Polymer Content? | X | X | X | |
| **Assurance of "Modified" Behavior** | | | | |
| Elastic Recovery @ 50F | X | X | X | |
| Phase Angle @ $T_{HIGH}$ | | | | X |
| **Assurance of Sprayability** | | | | |
| Viscosity @ 275F | X | X | X | X @ 205C |
| **Resistance to Bleeding @ $T_{HIGH}$** | | | | |
| ^DSR @ $T_{HIGH}$ | | X @ 58C | X @ 64C | X @ $T_{HIGH}$ |
| Viscosity @ 140F | X | X | X | |
| **Other Consistency** | | | | |
| Penetration @ 77F | X | X | X | |
| Softening Point | X | X | X | |
| **Resistance to Aggregate Loss @ $T_{LOW}$ after Aging** | | | | |
| ^PAV Aging | X w/RTFO | X w/RTFO | X w/RTFO | X |
| ^BBR Stiffness @ $T_{LOW}$ | X @-18C | X @ -18C | X @ -18C | X @ $T_{LOW}$ |
| ^BBR m-value @ $T_{LOW}$ | X @ -18C | X @ -18C | X @ -18C | |

| | CRS-2P | HFRS-2P | SPG |
|---|---|---|---|
| **Composition** | | | |
| Minimum Asphalt Content? | X | X | X |
| Solubility? | X | X | X |
| **Assurance of "Modified" Behavior** | | | |
| Ductility @ 39F | X | X | |
| Float Test @ 140F | | X | X (for HF) |
| **Assurance of Sprayability** | | | |
| Saybolt Viscosity @ 122F | X | X | X |
| **Emulsion-Specific Stability Tests** | | | |
| Demulsibility | X | X | X |
| Storage Stability & Sieve | X | X | X |

## EVOLUTION OF SPG

- TxDOT Research Project 0-1710 (3.5+ yrs, 45 field sections)
- NCHRP Research Project 14-17 (2.5+ yrs, 3 field sections)
- TxDOT Research Project 0-6616 (2 yrs, 30 field sections)

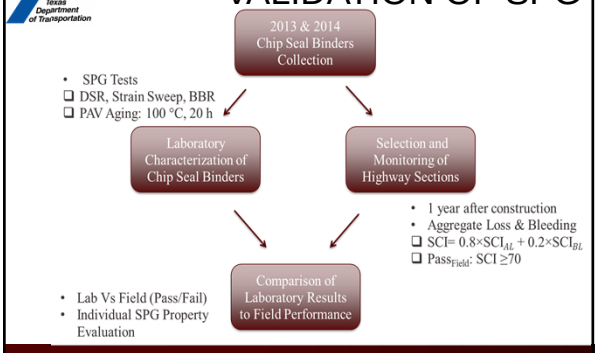
- SPG specification for chip seal/seal coat binders ***in service***
- Method B for emulsion residue recovery

- SPG specification part of system to be used ***with***
  - –design guidelines
  - –quality control procedures
  - –construction techniques

## EVOLUTION OF SPG

| Desired Performance | Lab Test | Performance Criteria | Threshold | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 2001 | 2005 | 2010 | 2012 | 2015 | 2016 |
| Resistance to Bleeding | DSR @ $T_{HIGH}$, Unaged | G*/sin δ (kPa), min | 0.75 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 |
| Polymer Modification | | δ, max @ $T_{HIGH}$ threshold | X | X | X | X | 80 UTI≥89 | 80 or 84 UTI≥86 |
| Resistance to Aggregate Loss | DSR @ $T_{INT}$ | % strain, min @ 0.8$G_{initial}$* (Unaged) | X | X | 25 | 17.5 | X | X |
| | | $G_{initial}$*(MPa), max (PAV) | X | X | 2.5 | 2.5 | X | X |
| Resistance to Aggregate Loss | BBR @ $T_{LOW}$ PAV | S (MPa), max @ 8 sec | 500 | 500 | 500 | 500 | 500 | 500 |
| Stress Relaxation | | m-value, min @ 8 sec | 0.24 | 0.24 | 0.24 | X | X | X |

## VALIDATION OF SPG

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## VALIDATION OF SPG

- TxDOT Implementation Project 5-6616

- 29 Binders, 19 Sections built in 2013
  - 89% Lab:Field Correlation @ $T_{HIGH}$
  - 68% Lab:Field Correlation @ $T_{LOW}$ @ 2yrs
  - Freq. Sweep – BBR: Poor correlation

- 16 Binders, 24 Sections built in 2014
  - 71% Lab:Field Correlation @ $T_{HIGH}$
  - 75% Lab:Field Correlation @ $T_{LOW}$

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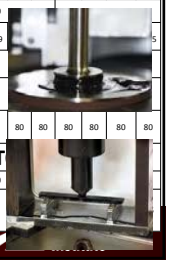
## 2016 SPG SPECIFICATION

| with PP 72 Method B Recovery<br>FP ≥ 230 by T 48<br>RV ≤ 0.15 Pa*s @ 205°C by T 316 | Performance Grade | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | SPG 64 | SPG 67 | | | | | SPG 70 | | | | | SPG 73 | | | | |
| | -25 | -13 | -16 | -19 | -22 | -25 | -13 | -16 | -19 | -22 | -25 | -16 | -19 | -22 | -25 |
| Average 7-day Maximum Surface Pavement Design Temperature, °C | <64 | <67 | | | | | <70 | | | | | | | | |
| Minimum Surface Pavement Design Temperature, °C | >-25 | >-13 | >-16 | >-19 | >-22 | >-25 | >-13 | >-16 | >-19 | | | | | | |
| **Original Binder** | | | | | | | | | | | | | | | |
| Dynamic Shear, T315 G*/Sinδ Minimum: 0.65 kPa Test Temperature @10 rad/s, °C | 64 | 67 | | | | | 70 | | | | | | | | |
| Phase angle (δ), Max, @ T where G*/sin δ = 0.65 kPa | 80 | – | – | – | 80 | 80 | – | – | 80 | 80 | 80 | 80 | 80 | 80 | 80 |
| **Pressure Aging Vessel (PAV) Residue (AASHT** | | | | | | | | | | | | | | | |
| PAV Aging Temperature, °C | 100 | | | | | | 100 | | | | | | | | |
| Creep Stiffness, T 313 S, Maximum: 500 MPa Test Temperature @ 8s, °C | -25 | -13 | -16 | -19 | -22 | -25 | -13 | -16 | -19 | | | | | | |



## 2016 SPG SPECIFICATION

| with AASHTO PP 72 Method B<br>FP ≥ 230 by T 48<br>RV ≤ 0.15 Pa*s @ 205°C by T 316 | Performance Grade<br>SPG 70 | | | | |
|---|---|---|---|---|---|
| | -13 | -16 | -19 | -22 | -25 |
| Avg 7-day Max Surface Pvmnt T, °C | <70 | | | | |
| Min Surface Pavement T, °C | >-13 | >-16 | >-19 | >-22 | >-25 |

- Method B for Emulsion Residue Recovery
  - Thin Film on Silicone Mat
  - 60 °C for 6 hrs

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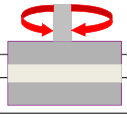
## 2016 SPG SPECIFICATION



| | Performance Grade<br>SPG 70 | | | | |
|---|---|---|---|---|---|
| | -13 | -16 | -19 | -22 | -25 |
| | <70 | | | | |
| | >-13 | >-16 | >-19 | >-22 | >-25 |
| **Original Binder** | | | | | |
| G*/Sinδ ≥ 0.65 kPa by T 315<br>Test Temperature @ 10rad/s, °C | 70 | | | | |
| Phase angle (δ), Max, @ temp. where G*/sin δ = 0.65 kPa | - | - | 80 | 80 | 80 |

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## 2016 SPG SPECIFICATION

| | Performance Grade | | | | |
|---|---|---|---|---|---|
| | SPG 70 | | | | |
| | -13 | -16 | -19 | -22 | -25 |
| | <70 | | | | |
| | >-13 | >-16 | >-19 | >-22 | >-25 |
| ***PAV Residue*** | | | | | |
| **S < 500 MPa by T 313** **Test Temperature @ 8s, °C** | -13 | -16 | -19 | -22 | -25 |

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## PG vs. SPG

| | PG | SPG |
|---|---|---|
| 1 | $T_{HIGH}$ = average 7-day max high $T_{pvmnt}$ @ 20mm | $T_{HIGH}$ = average 7-day max high $T_{pvmnt}$ @ ***surface*** |
| 2 | ±6°C @ $T_{HIGH}$ & $T_{LOW}$; -10 °C for $T_{LOW}$ grade | ±3°C @ $T_{HIGH}$ & $T_{LOW}$; ***No*** -10 °C for $T_{LOW}$ grade |
| 3 | DSR, T315, @$T_{HIGH}$ (RTFO) and @$T_{INT}$ (PAV) | ***No*** specification on RTFO aged binder & ***No*** $T_{INT}$ |
| 4 | Creep Stiffness, T 313, S and m-value @ 60s | Creep Stiffness, T 313, S @ ***8s; no m-value*** |
| 5 | No specification on δ at $T_{HIGH}$ | ***δ ≤ 80 @ continuous $T_{HIGH}$ for UTI ≥ 89*** |

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## SPG BINDER SELECTION

1. Determine Climate-Based SPG Grade by Map or Spreadsheet
2. Adjust SPG Grade for Traffic, Flexibility, & Modification
3. Compare with SPG Grades of Traditional Materials
4. Select Final SPG Grade

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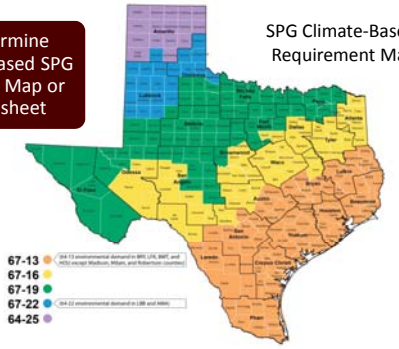
## SPG BINDER SELECTION

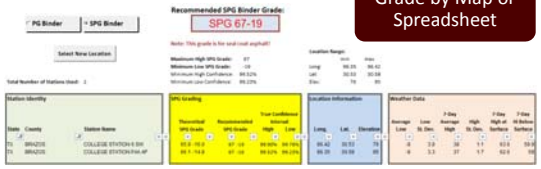
1. Determine Climate-Based SPG Grade by Map or Spreadsheet

SPG Climate-Based Requirement Map




## SPG BINDER SELECTION

1. Determine Climate-Based SPG Grade by Map or Spreadsheet

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## SPG BINDER SELECTION

2. Adjust SPG Grade for Traffic, Flexibility, & Modification

**Increase $T_{HIGH}$ for High Traffic** (Climate-Based Requirement)

- AADT < 500 SPG 67-19
- 500 < AADT < 5000
- AADT > 5000 SPG 73-19 (High Traffic)

**Decrease $T_{LOW}$ for Weak Pavement Structure**

**Increase UTI ≥ 89°C** to ensure polymer modification if desired

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## 2016 SPG BINDER SELECTION

3. Compare with SPG Grades of Traditional Materials

4. Select Final SPG Grade

| District | Environmental Requirement | Traditional Binder (2013/2014) | Selected SPG Grade with 3C |
|---|---|---|---|
| ABL | 67-19 | ---- | 73-19 |
| AMA | 64-25, 67-22 | AC20-5TR: 73-19<br>AC10-2TR: 67-22<br>AC10: 61-19 | 64-25 |
| AUS | 67-16, 67-13 | ---- | 70-19 |
| BWD | 67-19, 67-16 | AC10-2TR: 67-22 | CRS-2(67-22) |
| CRP | 67-13 | AC15P: 70-28, 73-28<br>CRS-2: 67-19 | 70-19 |
| PAR | 67-19 | AC20-5TR: 67-22 | 70-22 |
| PHR | 67-13 | AC15P: 70-31 | 73-16 |

## Field Performance Monitoring

- Visual Distress Survey
  - Aggregate Loss
  - Bleeding
  - Embedment

  - Pre-Construction
  - Post-Construction
  - @ 1 Year
- Binder & Aggregate Application Rates

- Time Between Material Application
- Weather Conditions

## INDUSTRY INTERACTION

- Technical Briefings
  - Suppliers
  - AGC of TX
  - TxAPA

- Presentations
  - WASHTO
  - ETF
  - AEMA/ARRA/ISSA
  - SEAUPG
  - ISAET
  - TRB

## INDUSTRY INTERACTION

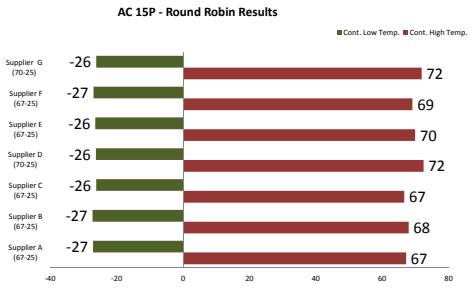
SPG Round Robin 1

- Fall/Winter 2015-16
- AC-15P & CRS-2P
- with & without Reheating for $T_{HIGH}$ , time effects
- δ @ threshold, grading T
- 5 suppliers + TxDOT + TTI
- Debriefings

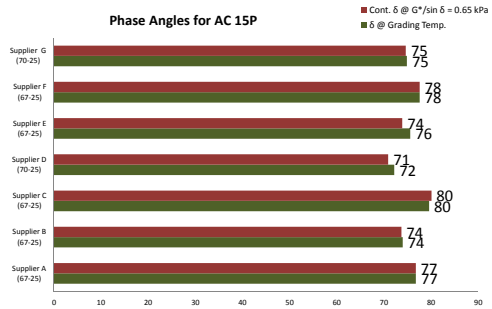
SPG Round Robin 2

- Summer/Fall 2016
- SPG Hot-Applied & Emulsion
- 10 suppliers + TxDOT + TTI
- 6 $^0$C increments
- 2 replicates @ $T_{HIGH}$
- Polymer modification
  - Elastic Recovery @ 50 $^0$F
  - MSCR @ 55 $^0$C and 61$^0$C
  - m-value for information only

## SPG ROUND ROBIN - 1




## SPG ROUND ROBIN - 1



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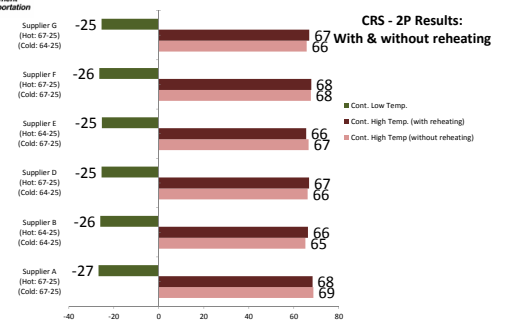
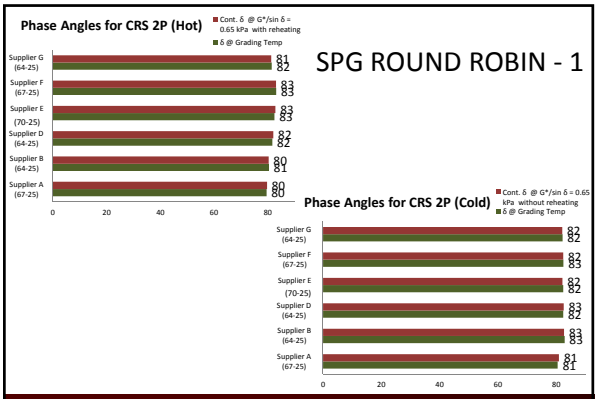



## SPG ROUND ROBIN - 1




## ROUND ROBIN 1 RESULTS

- Results rounded to nearest 1°C due to precision & bias
- For both, Very Good agreement @ $T_{LOW}$
- For both, Good agreement @ $T_{HIGH}$, with both @ threshold & AC-15P more variable.

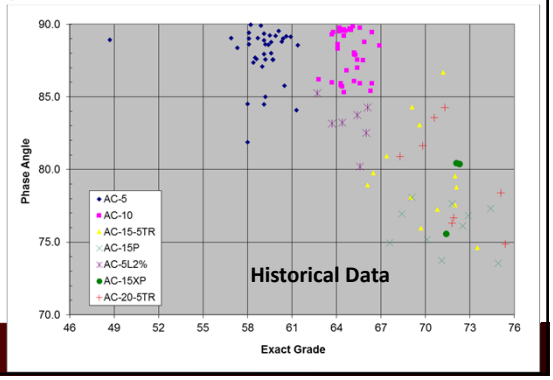
- Considering precision & bias, 3°C SPG increment too tight @ $T_{HIGH}$.
- Considering precision & bias, 3°C SPG increment ok @ $T_{LOW}$.

## ROUND ROBIN 1 RESULTS

- For practicality, 6°C increments proposed @ $T_{HIGH}$ & $T_{LOW}$

- Offset SPG temperatures (from those for PG) proposed
  - capture statewide 67°C climate in TX
  - make SPG grades unique and fewer in number
  - possibly decrease adjustments needed from climate-based requirement
- No difference (within 1°C) in 2 procedures (with & without reheating) considering precision & bias
- No changes to δ requirement for UTI ≥ 89 proposed with majority showing no difference (within 1°) between the value @ the threshold & that @ the grading T

## PHASE ANGLE DATA




## 2017 SPG SPECIFICATION

| with PP 72 Method B Recovery<br>FP ≥ 230 by T 48<br>RV ≤ 0.15 Pa*s @ 205°C<br>by T 316 | Performance Grade | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | SPG 67 | | | | SPG 73 | | | | SPG 79 | | | |
| | -13 | -19 | -25 | -31 | -13 | -19 | -25 | -31 | -13 | -19 | -25 | -31 |
| Average 7-day Maximum Surface Pavement Design Temperature, °C | <67 | | | | <73 | | | | <79 | | | |
| Minimum Surface Pavement Design Temperature, °C | >-13 | >-19 | >-25 | >-31 | >-13 | >-19 | >-25 | >-31 | >-13 | >-19 | >-25 | >-31 |
| **Original Binder** | | | | | | | | | | | | |
| Dynamic Shear, T315<br>G*/Sinδ Minimum: 0.65 kPa<br>Test Temperature @10 rad/s, °C | 67 | | | | 73 | | | | | | | |
| Phase angle (δ), Max, @ T where G*/sin δ = 0.65 kPa | — | 80 | 80 | 80 | 80 | 80 | 80 | 80 | | | | |
| **Pressure Aging Vessel (PAV) Residue (AASHTO PP1)** | | | | | | | | | | | | |
| PAV Aging Temperature, °C | 100 | | | | 100 | | | | | | | |
| Creep Stiffness, T 313<br>S, Maximum: 500 MPa<br>Test Temperature @ 8s, °C | -13 | -19 | -25 | -31 | -13 | -19 | -25 | -31 | | | | |

## 2017 SPG SPECIFICATION

| with AASHTO PP 72 Method B Recovery<br>FP ≥ 230 by T 48<br>RV ≤ 0.15 Pa*s @ 205°C by T 316 | Performance Grade SPG 73 | | | |
|---|---|---|---|---|
| | -13 | -19 | -25 | -31 |
| Avg 7-day Max Surface Pavement T, °C | <73 | | | |
| Min Surface Pavement T, °C | >-13 | >-19 | >-25 | >-31 |

- Method B for Emulsion Residue Recovery
  - Thin Film on Silicone Mat
  - 60 °C for 6 hrs

6°C INCREMENTS OFFSET FROM PG

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## 2017 SPG SPECIFICATION

δ REQUIRED FOR UTI ≥ 86°C @ $T_{HIGH}$ THRESHOLD

| *MAX δ FOR EMULSION RESIDUE = 84 | Performance Grade SPG 73 | | | |
|---|---|---|---|---|
| | -13 | -19 | -25 | -31 |
| | <73 | | | |
| | >-13 | >-19 | >-25 | >-31 |
| **Original Binder** | | | | |
| G*/Sinδ ≥ 0.65 kPa by T 315<br>Test Temperature @ 10rad/s, °C | 73 | | | |
| Phase angle (δ), Max, @ temp. where G*/sin δ = 0.65 kPa | 80* | 80* | 80* | 80* |

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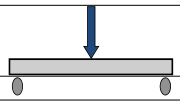
## 2017 SPG SPECIFICATION



| | Performance Grade SPG 73 | | | |
|---|---|---|---|---|
| | -13 | -19 | -25 | -31 |
| | <73 | | | |
| | >-13 | >-19 | >-25 | >-31 |
| ***PAV Residue*** | | | | |
| S ≤ 500 MPa by T 313<br>Test Temperature @ 8s, °C | -13 | -19 | -25 | -31 |

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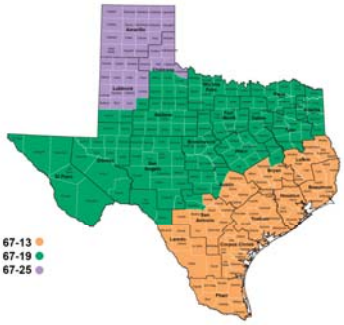
## SPG BINDER SELECTION w/6°C increments @ $T_{HIGH}$ & $T_{LOW}$

Revised SPG Climate-Based Requirement Map




## EFFECTS of SPG

- Performance-Related specification tied to specific climate & traffic
- Each material meets a grade
- Less variability within grades
- More competition
- Higher performing binders by current spec still higher performing binders
- Current Tier Selection Table to be replaced by SPG Binder Selection guidelines
  - Retain selection of material type (hot applied or emulsion)
  - Retain allowance for wider SPG grade with payment at narrower grade
  - Retain season restrictions by district

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## CHALLENGES of SPG

- CHANGE
- New recovery procedure
- Requires BBR
- Some differences between PG & SPG

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## NEXT STEPS

- Complete 2016 Verification
  - 8 Binders, 15 Sections in 7 Districts
- Complete Round Robin 2
- Continue Gathering Industry Input
- Resubmit to AASHTO & ASTM & Respond
- Document & Market with TxDOT, TTI Communications
- Adjust to CHANGE in Formulations

## Contact

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