EXTERNAL PIM REMEDIATION

Using PIM Shield™ Roofing Technology

PIM SHIELD

ConcealFab® *Corporation*

Executive Summary

ConcealFab Corp has worked with Johns Manville, a global leader in the roofing industry (www.jm.com), to co-develop reliable roofing materials to reduce passive intermodulation at rooftop cell sites. At the site described in this report, PIM levels were improved on average by >40 dB per line in the 700 MHz band by installing PIM Shield™ roofing material.

PIM Shield Roofing System Installed

Materials Used

The PIM mitigating material installed at this site was DynaLastic™ 180 FR PIM. This is a multiply Styrene-Butadiene-Styrene (SBS) modified bitumen roof membrane manufactured by Johns Manville and sold through ConcealFab. The material includes ceramic coated roofing granules bonded to the top surface with a special PIM mitigating layer sandwiched in the middle between two SBS modified bitumen layers. The material can be installed using industry standard hot asphalt or cold adhesive processes.
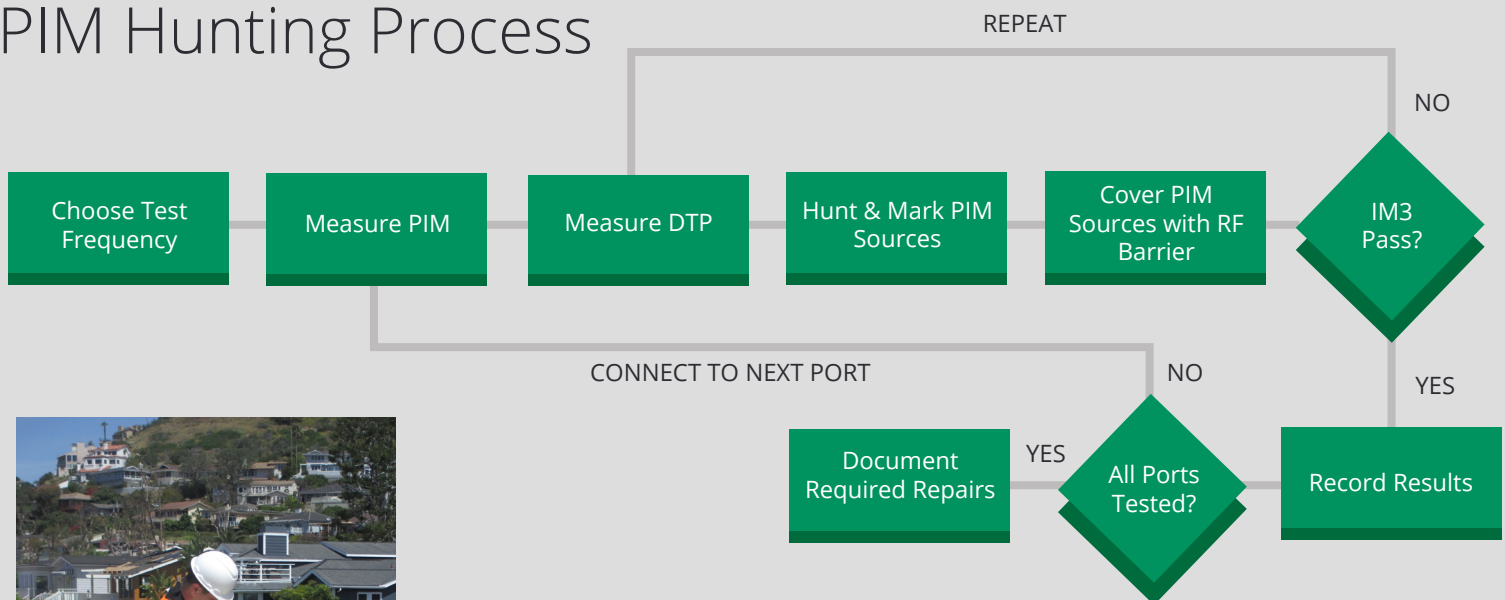
For this installation, Johns Manville MBR bonding and flashing adhesives were used to attach the membrane to the existing roofing surface. Johns Manville TopGard 4000 acrylic elastomeric coating was applied after installation for added protection and to meet aesthetic requirements. The material system complies with the applicable ASTM standards and carries both UL and FM approvals.

Remediation Process

Vertical Limit Construction (www.verticallimit.com) performed the RF measurements on this site following the external PIM investigation process outlined in the chart below. A Kaelus iQA-700H with RTF module was used to measure PIM, an Anritsu MS2720T with PIM Hunter probe was used to identify PIM source locations and ten ConcealFab PIM blankets, part number 007640-120060, were used to cover the PIM sources once identified.

A significant percentage of the area in front of and directly below the sector antennas was found to be generating PIM. Covering those areas with PIM blankets reduced the sector PIM to better than -90 dBm on all ports. PIM Blankets are useful as an aide during the test & measurement process but are not suitable as a long-term mitigation solution.

PIM Hunting Process

REPEAT

NO

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Choose Test Frequency → Measure PIM → Measure DTP → Hunt & Mark PIM Sources → Cover PIM Sources with RF Barrier → IM3 Pass?
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CONNECT TO NEXT PORT

NO

YES

Document Required Repairs

All Ports Tested?

Record Results

YES

Initial Results

Port Identification	Starting PIM	PIM with Blankets Deployed	Improvement
1 Violet	-54.1 dBm	-90.1 dBm	36.0 dB
2 Violet	-55.9 dBm	-95.5 dBm	39.6 dB
3 Violet	-52.0 dBm	-97.2 dBm	45.2 dB
4 Violet	-62.2 dBm	-91.7 dBm	29.5 dB

PIM Blankets Deployed

PIM Shield™ roofing material was deployed over the impacted area then permanently installed using MBR bonding and flashing adhesives per Johns Manville standard installation procedures. After installation, PIM was measured again to validate performance. A small area directly below one antenna required additional coverage to achieve the desired PIM performance. This area had been covered during the PIM blanket deployment but had accidentally not been covered with roofing material.

Results with PIM Shield™ Roofing Installed

Port identification	Starting PIM	PIM Shield™ Installed	Improvement
1 Violet	-54.1 dBm	-94.8 dBm	40.7 dB
2 Violet	-55.9 dBm	-99.3 dBm	43.4 dB
3 Violet	-52.0 dBm	-106.2 dBm	54.2 dB
4 Violet	-62.2 dBm	-101.2 dBm	36.2 dB

PIM Shield Roofing Installed

Completed System with TopGard coating applied

For added protection and to meet local aesthetic requirements, a layer of TopGard 4000 acrylic elastomeric coating was applied over the PIM Shield™ roofing material.

Conclusion

PIM Shield™ roofing material has proven its ability to significantly reduce external PIM on rooftop sites. The material is based on Johns Manville's standard SBS modified bitumen roofing membrane, a proven material capable of providing decades of reliable service in rooftop environments.   The material can be installed using industry standard processes and meets applicable code requirements. PIM Shield™ roofing material provides mobile operators a reliable method to improve network performance by reducing external PIM on rooftop sites.

Appendix A - Supporting Data

Notes:

1) Measurements were conducted at the radio output. Results shown include the contribution from the antenna plus feed cable.

2) The Range-To-Fault (RTF) calibration point was at the output of the PIM analyzer. Displayed distances included the length of the test cable (approximately 10 FT)

3) Initial RTF measurements were made with the velocity factor (vf) set to 0.82. This is the correct value for trouble shooting problems inside the feed system but not correct for troubleshooting problems beyond the antenna. The velocity factor was changed to 0.99 (closest to 1.0 that the Kaelus equipment would allow) for "after" RTF measurements.

4) PIM test parameters:
   a. F1 = 728 MHz
   b. F2 = 757 MHz
   c. IM3 = 786 MHz
   d. Test power = 43 dBm per test tone
   e. Test duration = 30s

Line 1:
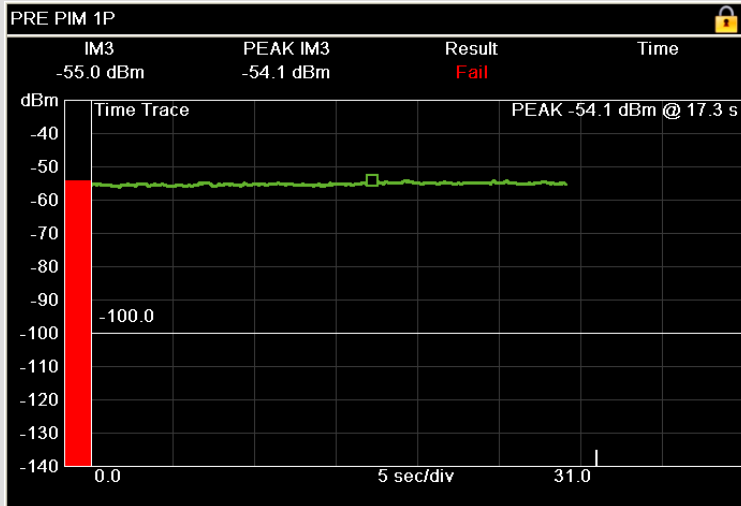
Starting PIM: -54.1 dBm
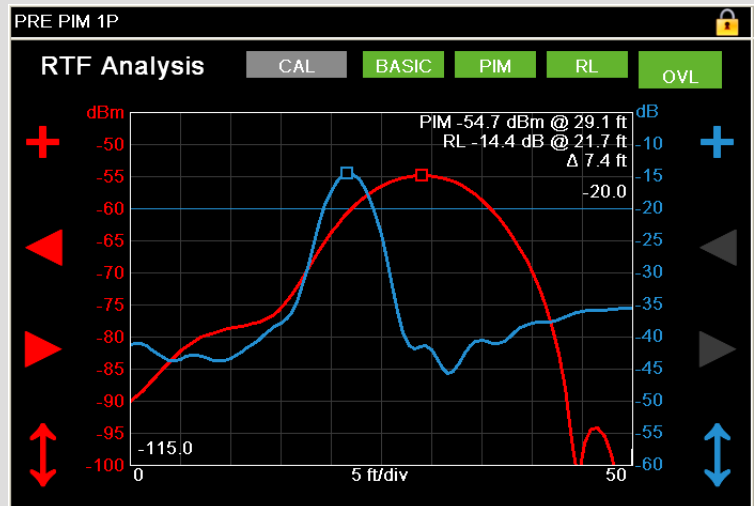
Starting RTF (vf = 0.82)
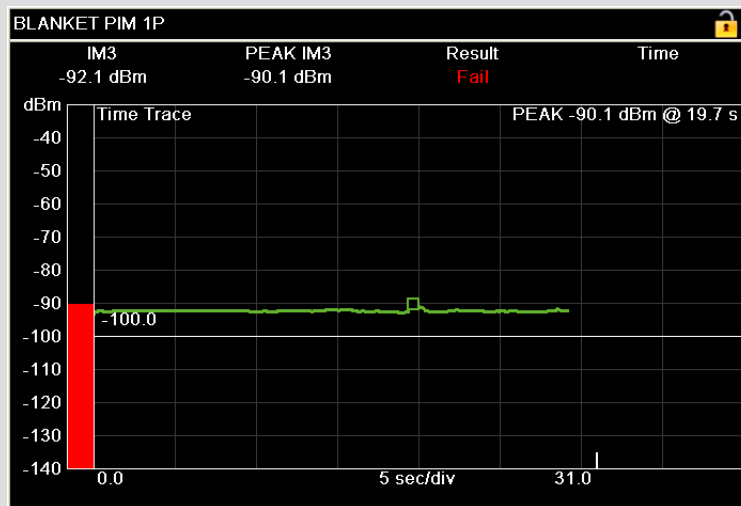
PIM Blankets Deployed: -90.1 dBm
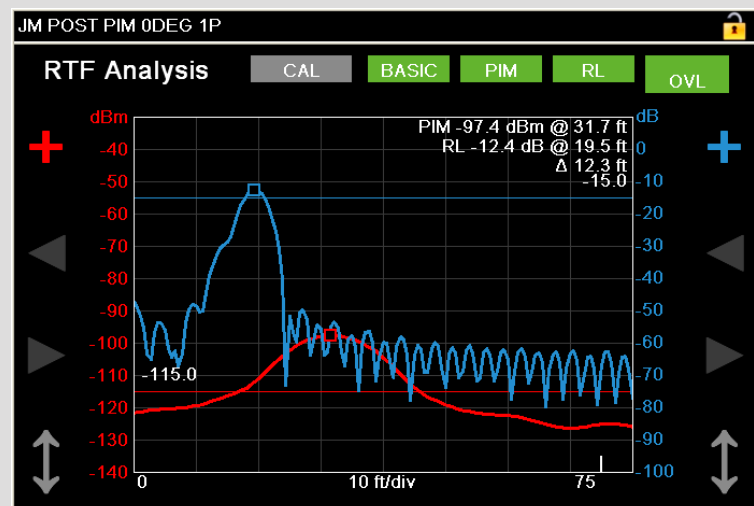
Ending RTF (vf = 0.99)
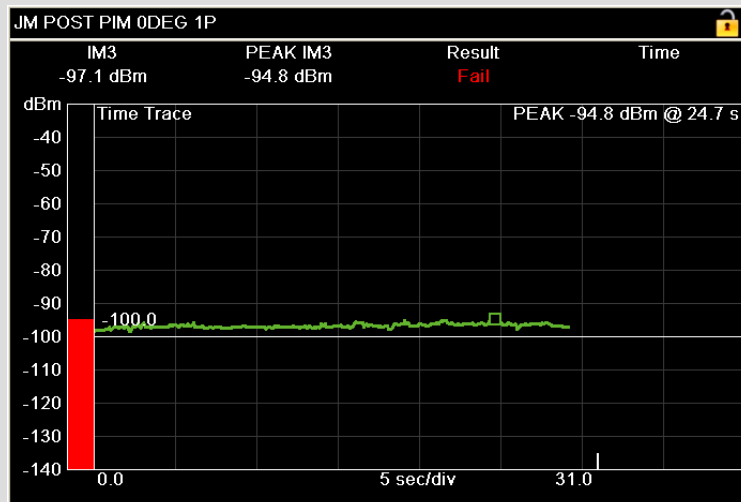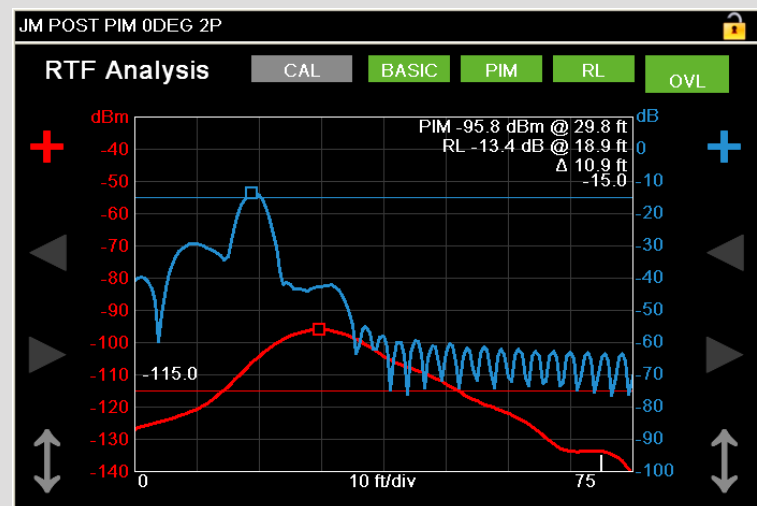

PIM Shield Bonded: -94.8 dBm

Line 2:
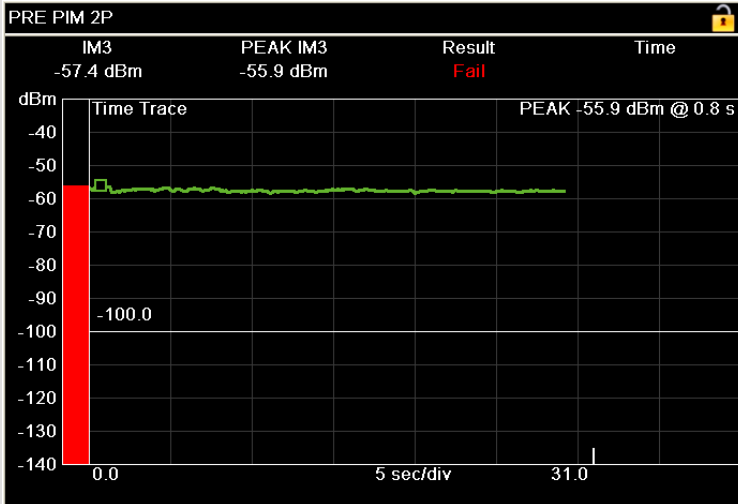
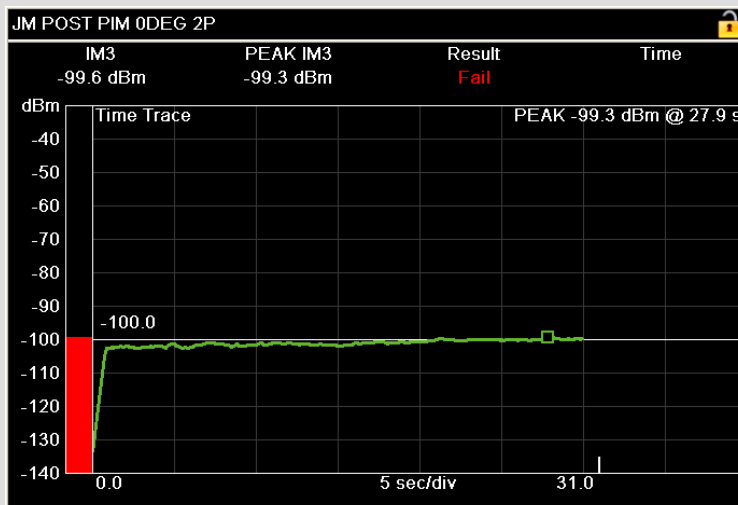**Starting PIM: -55.9 dBm**
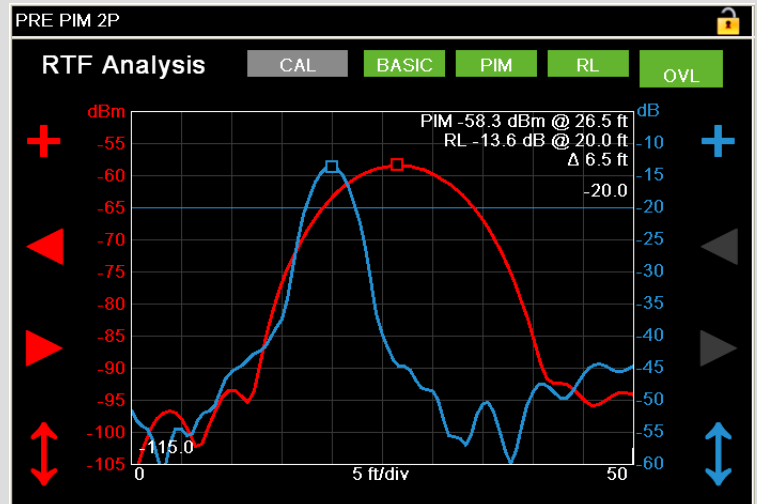
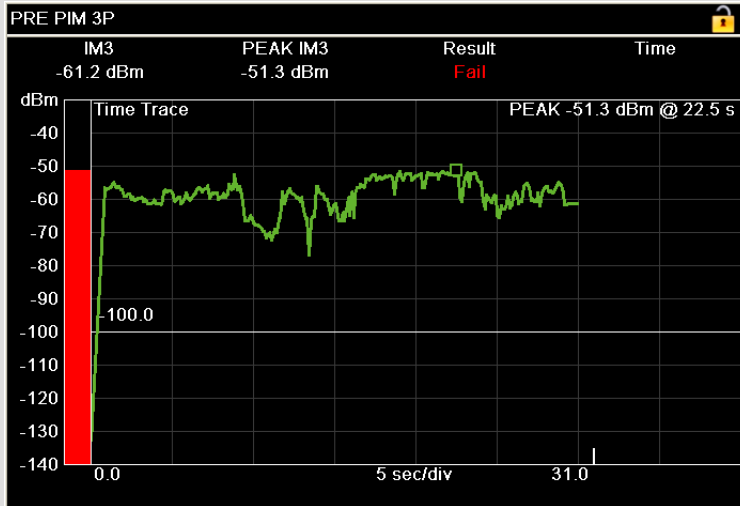**Starting RTF (vf = 0.82)**
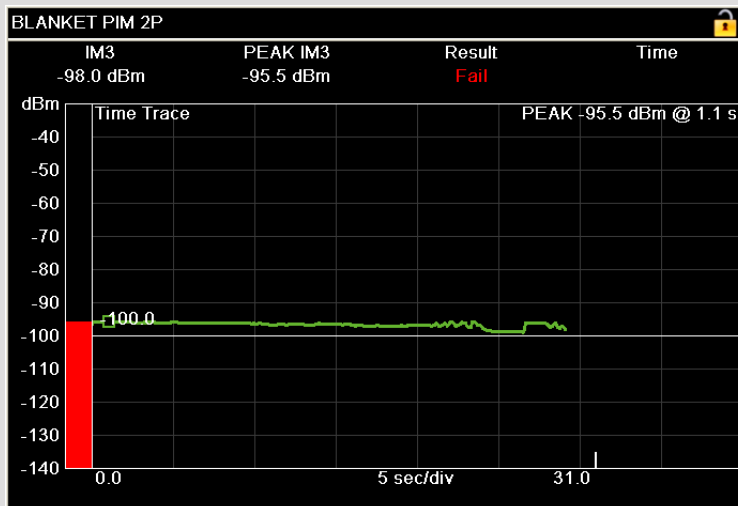
PIM Blankets Deployed: -95.5 dBm
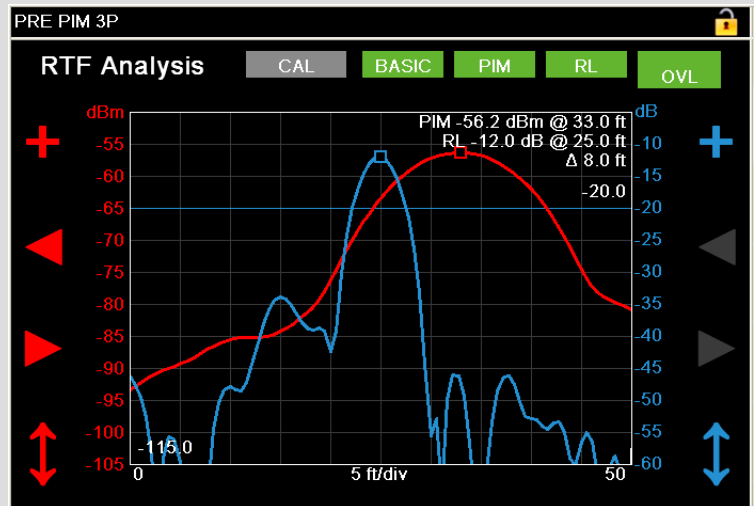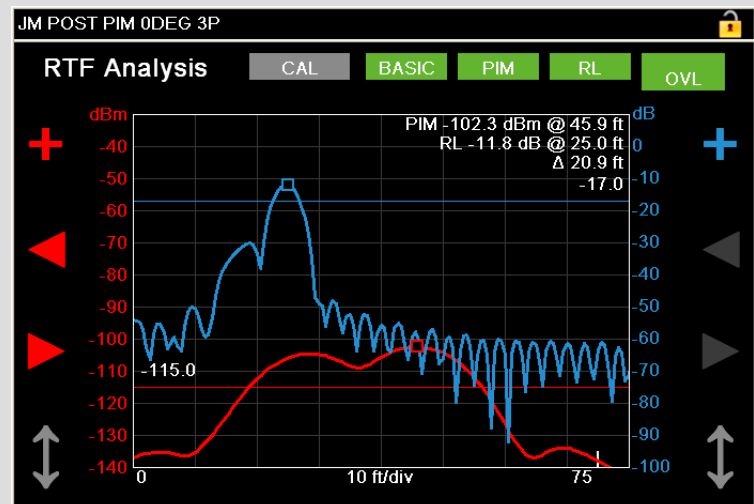

Ending RTF (vf = 0.99)

PIM Shield Bonded: -99.3 dBm
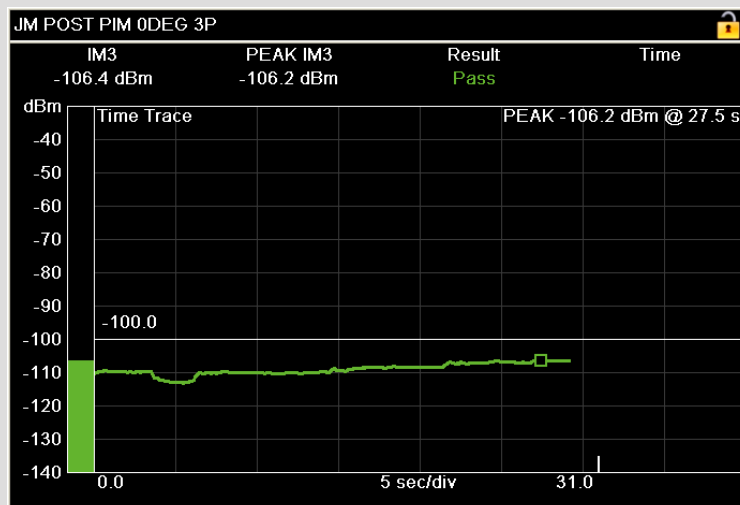
Line 3:

Starting PIM: -51.3 dBm

Starting RTF (vf = 0.82)

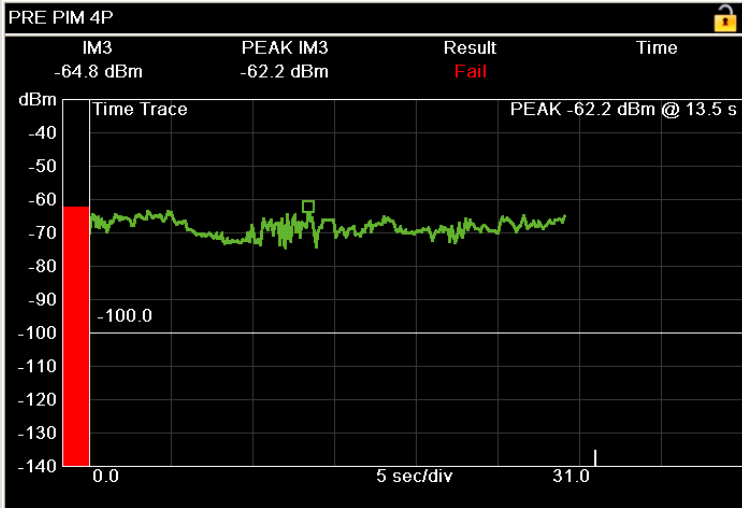**PIM Blankets Deployed: -97.2 dBm**
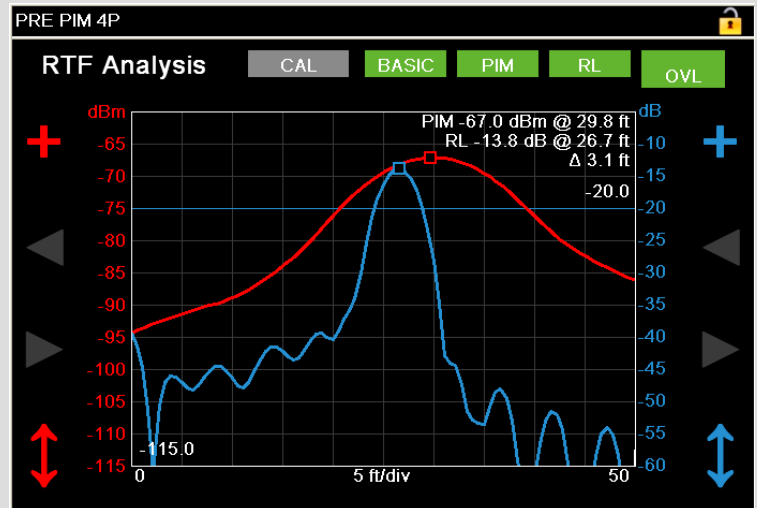

Ending RTF (vf = 0.99)

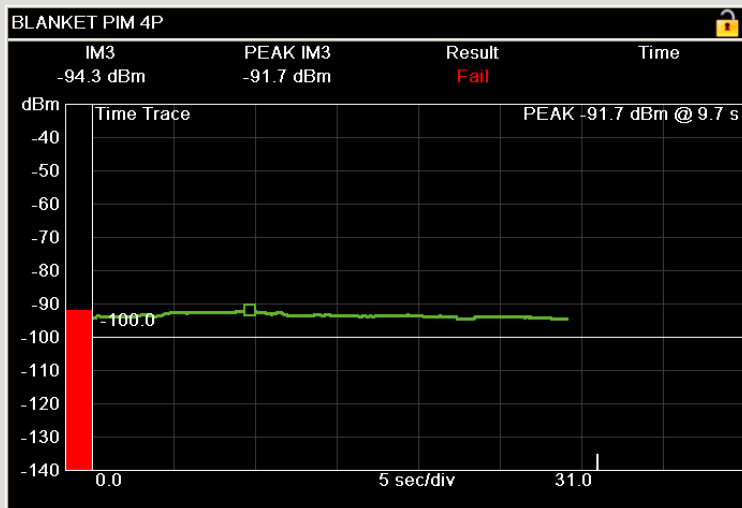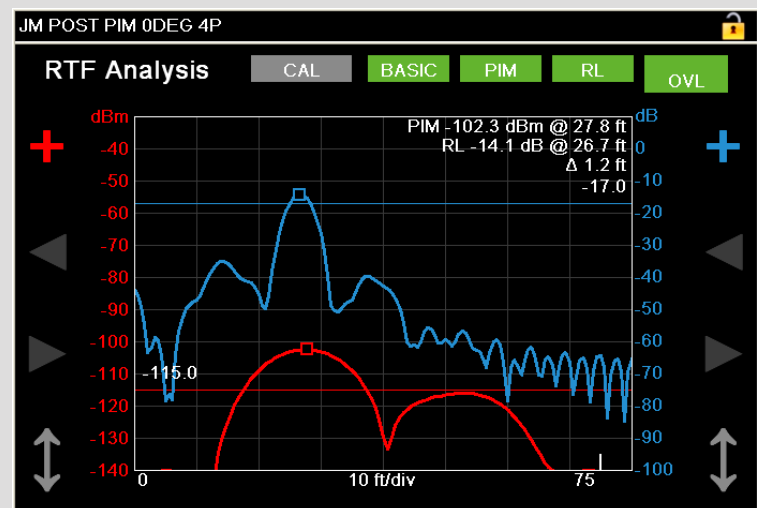**PIM Shield Bonded: -106.2 dBm**
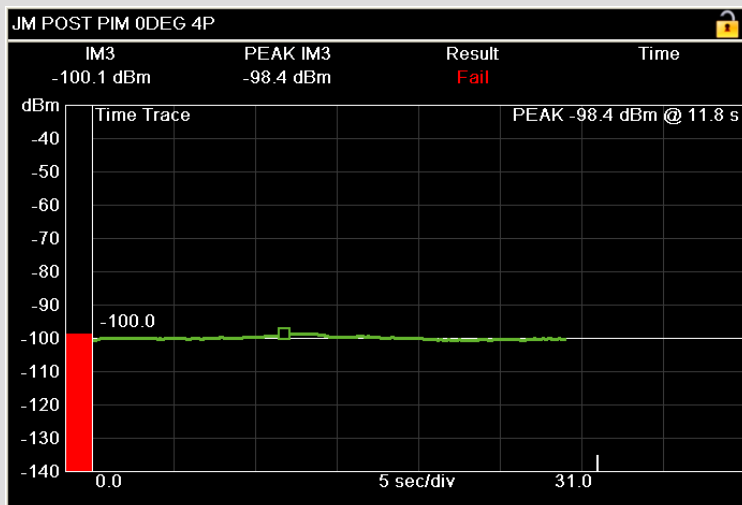
Line 4:

Starting PIM: -62.2 dBm

Starting RTF (vf = 0.82)

PIM Blankets Deployed: -91.7 dBm

Ending RTF (vf = 0.99)

PIM Shield Bonded: -98.4 dBm

ConcealFab®
Corporation

3525 N Cascade Avenue
Colorado Springs, CO 80907

719.599.3400
info@concealfab.com
www.concealfab.com

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