The Advantage of Evonik's Innovative Polycarbamide Technology for Industrial Direct-to-Metal Coatings & Topcoat Applications

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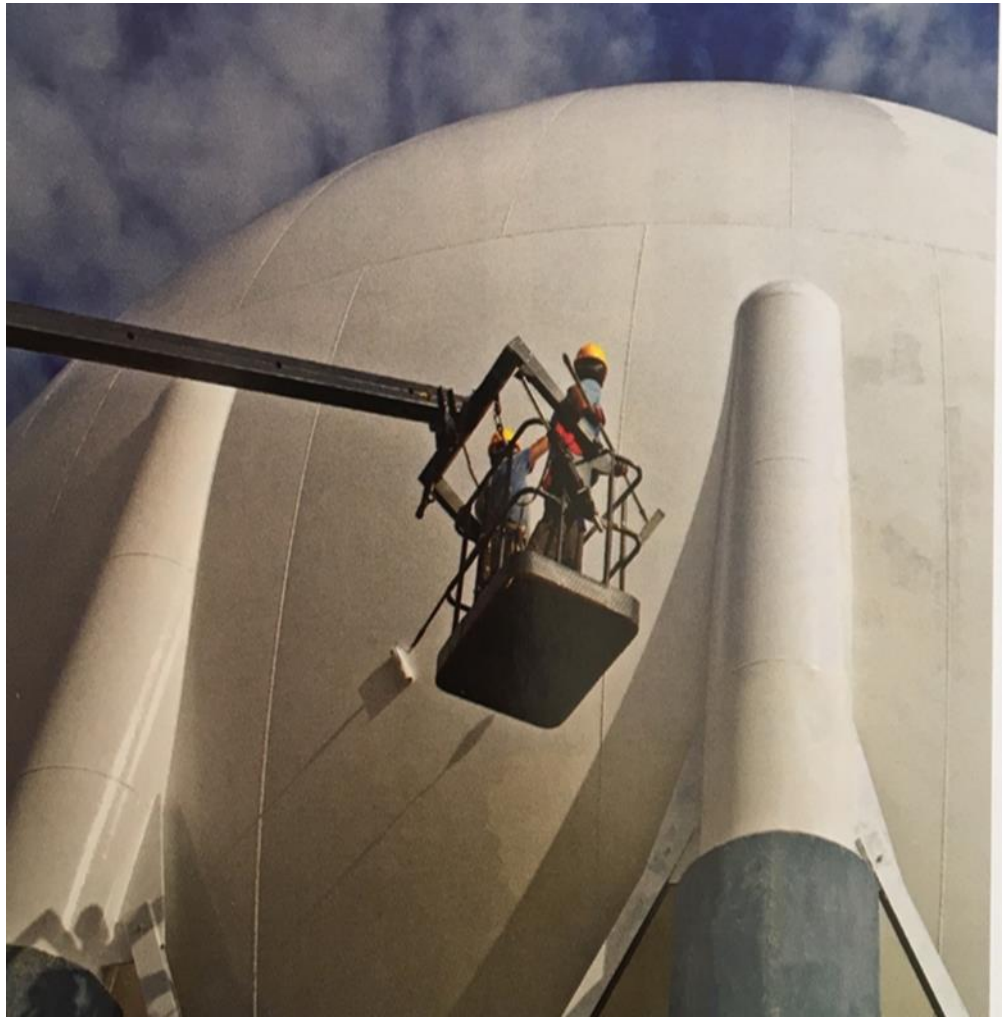
Agenda

1. Polycarbamide technology
2. Direct to metal coating applications
3. Topcoat applications
4. Results and discussion
5. Summary



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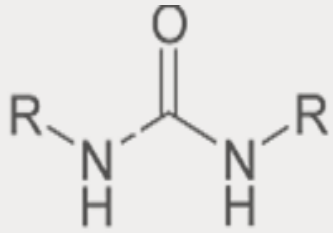
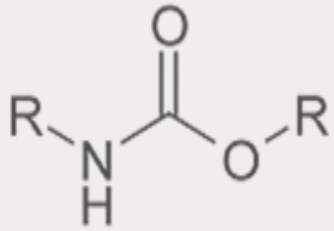
Polycarbamide is the Advanced Polyaspartics Technology for Coatings Applications

- Advantages:
  - Fast cure time
  - Excellent UV-resistance
  - Durability
  - Low temperature cure
  - Corrosion protection
- Application
  - Directly to Metal (DTM)
  - Topcoat

Key moieties within the polymeric cross-linked systems.



Polycarbamide



Polyurethane

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Direct to Metal (DTM) Polycarbamide Coatings

- DTM coatings are most often used in C3 environments (ISO 12944)

2K PUR topcoat

Primer

→

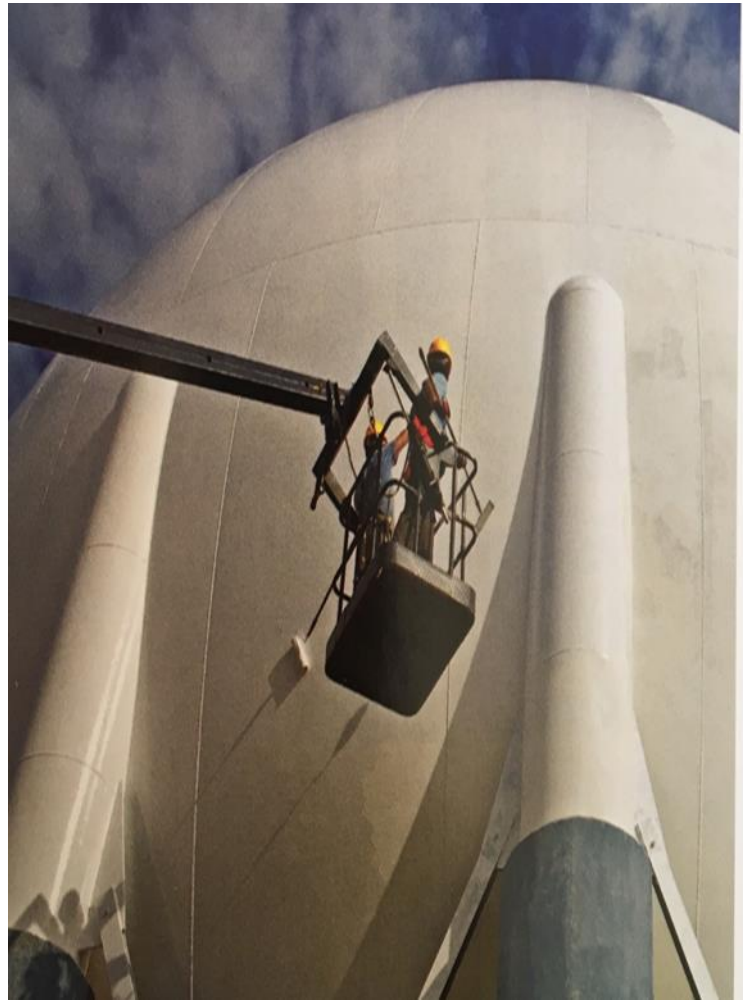
DTM polycarbamide coating

Applications:

- OEM
- Light industrial
- Structural steel
- Storage tanks – external

Advantages:

- Lower total system cost
- Increased productivity
- Ease of application
- Reduced formulation complexity

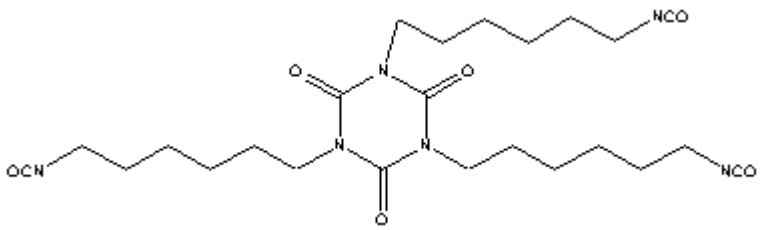


Evonik Polycarbamide Products: Amicure® IC-166 and IC-186

Polycarbamide	Solids content (%)	Equivalent weight	Viscosity (cP)
Amicure® IC-166	100	267	1500
Amicure® IC-186	100	268	1000

***Polyisocyanates** – Various commercial suppliers

- Ex. of an hexamethylene diisocyanate (HDI) trimer



Product recommendations:

- **IC-166** - a fast cure at low temperature and low humidity conditions
- **IC-186 -** a slower cure product with longer working time, better for higher temperature and humidity environments
- Amicure ® IC -166 and IC-186 are compatible with each other and can be blended together to provide formulations with required handling and performance

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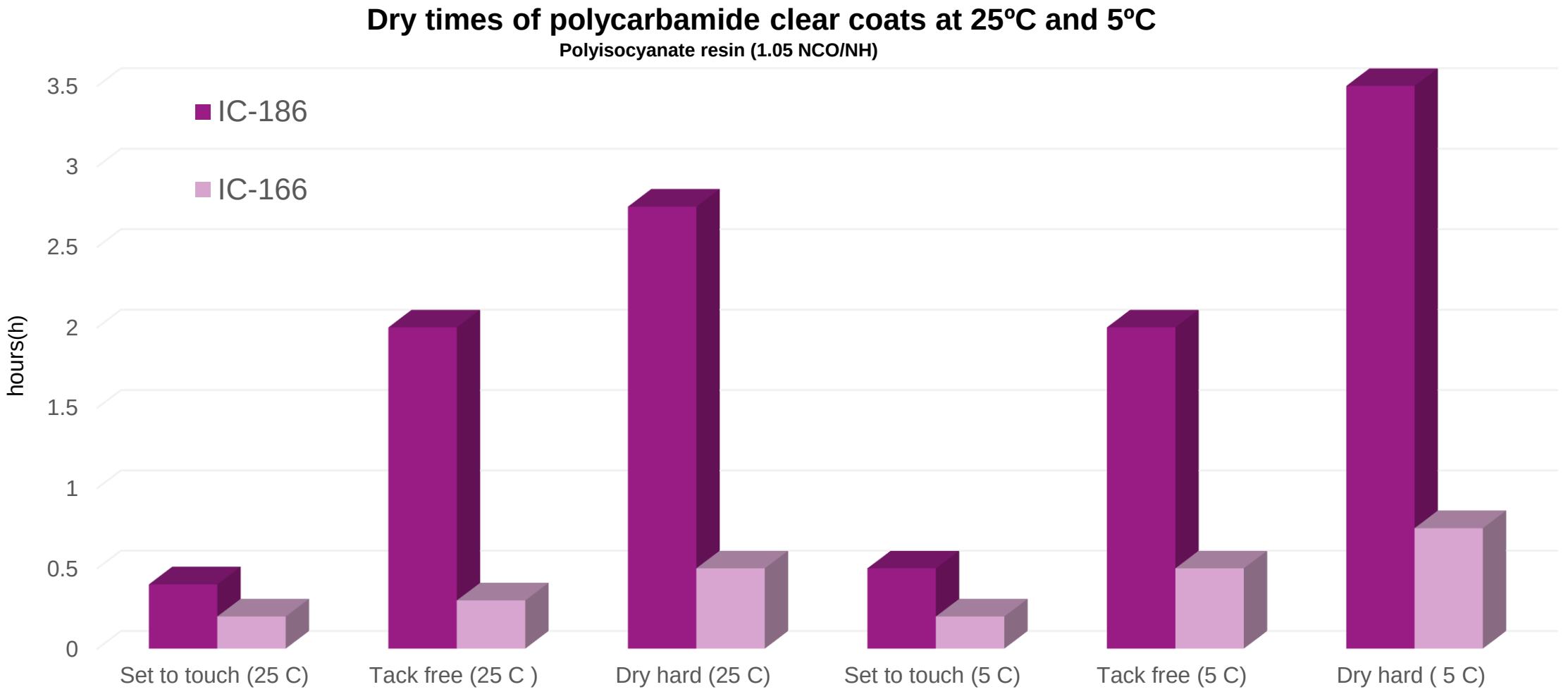
Fast Return to Service with Amicure ® IC-166 and IC-186 Products Will Maximize Productivity at the Job Site



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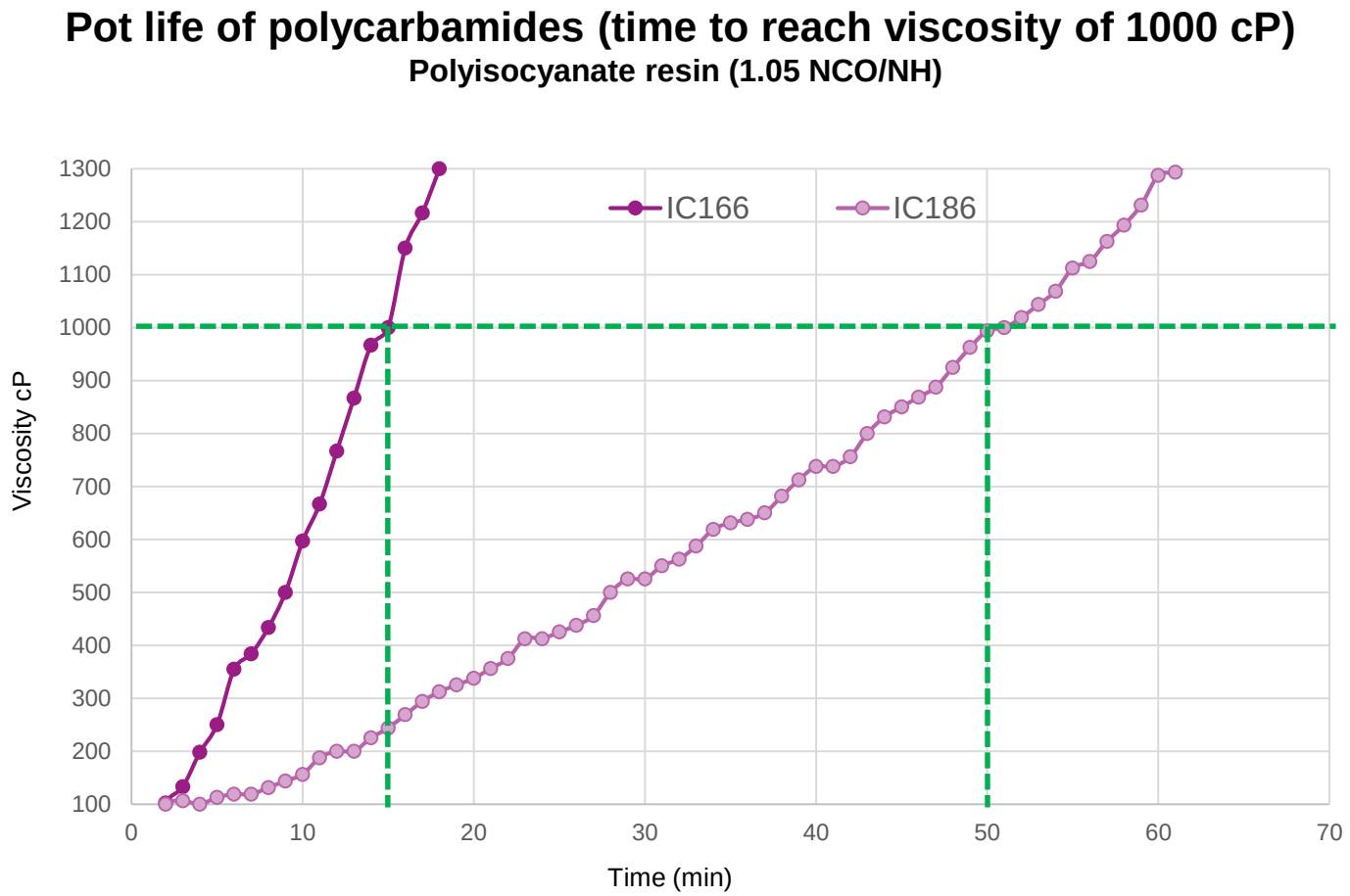
Increased Working Time with Amicure ® IC-186 Allows a Flexibility in End-use Application



- Amicure IC-186 provides ˜50 minutes of pot life when formulated to 250g/l VOC which enables it be applied using conventional spray guns
- Amicure IC-166 provides ˜ 15 minutes of pot life in 250g/l VOC formulations

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Polycarbamide Performance vs 2K Polyurethane DTM and Traditional Polyaspartics

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Polycarbamide DTM Model Formulations

	Amicure IC-186		Amicure IC-166		Amicure IC-186 and IC-166		
Raw Materials	**Lbs**	**Gal**	**Lbs**	**Gal**	**Lbs**	**Gal**	**Supplier**
Part A							
Amicure IC-166			304.5	32.3	152.2	16.2	Evonik
Amicure IC -186	305.8	33.4			152.9	16.7	Evonik
BYK 163	7.9	1.0	7.9	0.9	7.9	1.0	BYK
Tipure R 960 TiO2	289.0	10.4	287.0	8.7	287.0	8.7	Chemours
Heucophos ZAPP	61.2	0.7					Heaubach
Zinc Phosphate			60.9	2.6	60.8	2.6	Heaubach
Part A Total	**664.0**	**45.4**	**660.2**	**44.6**	**660.8**	**45.1**	
Part B							
HDI Trimer	228.9	24.3	228.0	23.6	226.6	23.4	
Methyl Amyl Ketone	206.3	30.3	213.2	32.0	212.4	31.9	Eastman
Part B Total	**425.7**	**54.6**	**441.2**	**55.5**	**439.0**	**55.3**	
Part A + Part B	**1090.2**	**100.0**	**1102.0**	**100.0**	**1099.0**	**100.0**	
Formulation Properties	**Values**		**Values**		**Values**		
Weight per Gallon (lb/gal)	10.9		11.0		11.0		
Non Volatile weight (lb)	80.0		80.2		79.0		
Non Volatile volume (gal)	68.6		68.0		68.0		
PVC (%)	15.3		14.0		14.0		
VOC(lbs/gal)	2.2		2.2		2.2		
VOC(g/l)	263.0		263.0		263.0		

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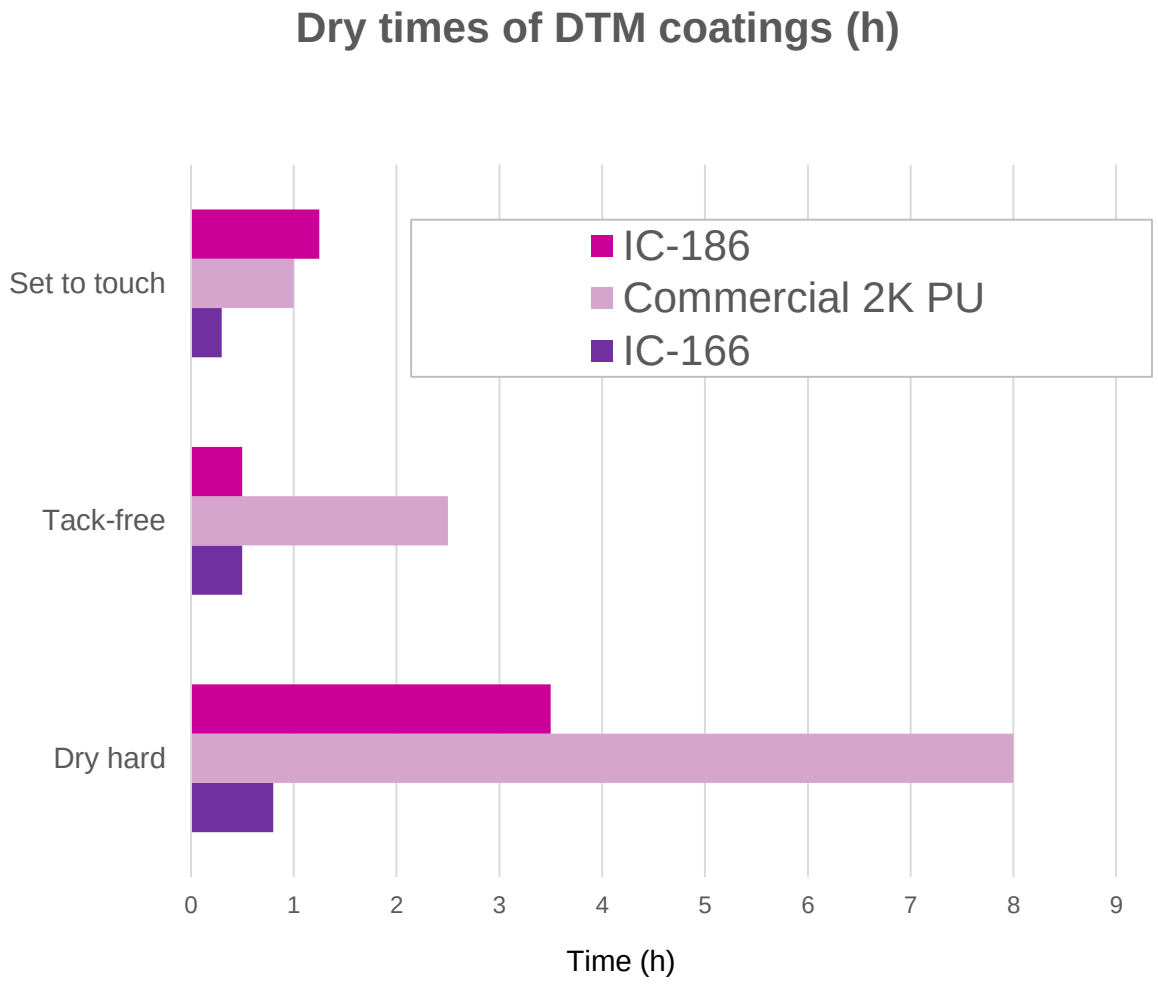
Polycarbamide Technology Provides a Much Faster Return To Service vs 2K Polyurethane DTM

Coatings physical properties	IC-166 DTM	IC-186 DTM	2K PUR DTM
PVC %	14	15	17
Volume solids %	68	69	53-61
Weight solids %	80	80	58-71
VOC (g/l)	**250**	**250**	**313**

Coatings prepared to 3 mil DFT



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Excellent Performance of Polycarbamide Coatings Similar to 2K Polyurethane DTM with Faster Return to Service

Property	IC-186	IC-166	2K DTM Polyurethane
Dry had time (h)	**3.5**	**0.8**	**8**
Water immersion (24 h)	Pass	Pass	Pass
Tape adhesion (dry, wet)	5A,5A	5A, 5A	5A, 5A
Direct/reverse impact flex (in-lbs)	160/160	160/160	160/160
Mandrel bend (in)	Pass 1/8”	Pass 1/8”	Pass 1/8”
Persoz hardness	179	191	190
MEK & toluene immersion (24 h)	Pass	Pass	Pass

Water Immersion, Tape adhesion, Impact , Persoz hardness, Water and solvent resistance: tested on Bondrite 952 Panels (3mils DFT)
Mandrel Bend test: Treated Aluminum panel (3 mils DFT)

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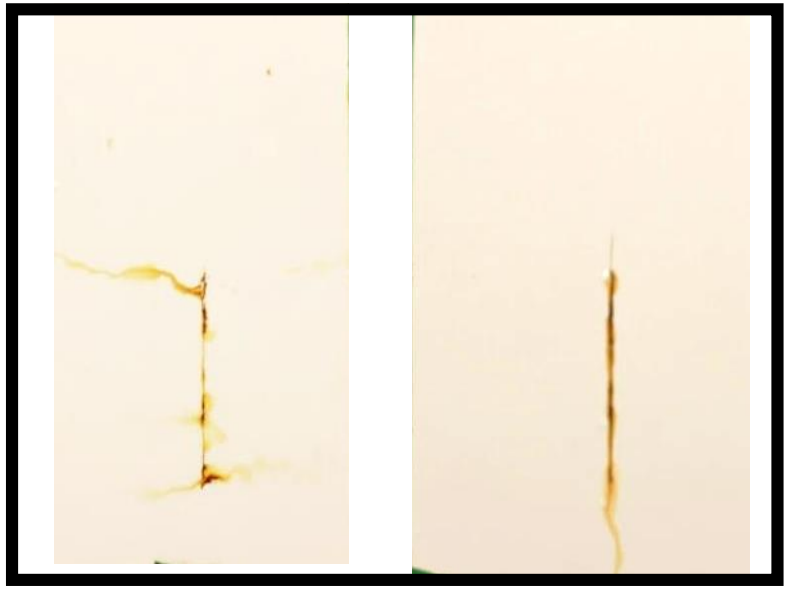
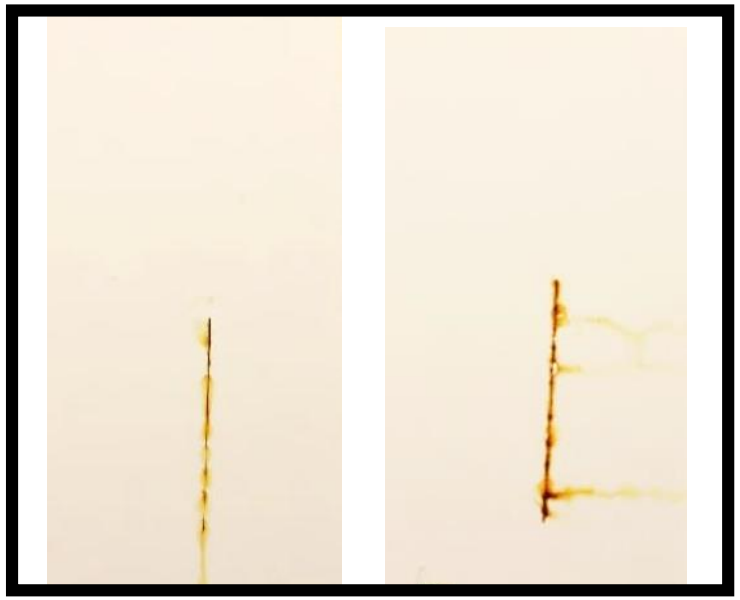
Polycarbamide Coatings Provide Good Corrosion Resistance Comparable to 2K Polyurethane

IC-186 DTM



Cold rolled steel | Sand blasted steel

IC-186/ IC-166 DTM



Cold rolled steel | Sand blasted steel

2K PU

Cold rolled steel

Cold rolled steel	ASTM method	IC-186 DTM	2K PU DTM	IC-186/IC-166 DTM
Corrosion creep*	D1654	10	10	10
Face blisters	D714	None	None	None
Adhesion**	D1654	9	9	9

**Corrosion creep is on a scale of 1 to 10 where 10 does not show any creep*

***Adhesion is on a scale of 1 to 10 where 10 indicates complete adhesion*

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Similar Chemical Resistance Performance to that of 2K PU DTM

Chemical resistance: 24 h spot test using Bondrite 952 panels

Chemical	IC-166	IC-186	2K Polyurethane
Xylene	Slight swell	Slight swell	Slight swell
10% NaOH	No effect	No effect	No effect
10% H_2SO_4	No effect	No effect	No effect
10% HNO_3	Slight stain	Slight stain	Slight stain
Hydraulic oil	No effect	No effect	No effect
Gasoline	No effect	No effect	No effect
Diesel fuel	No effect	No effect	No effect
Water	No effect	No effect	No effect

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Key Advantages For Amicure® IC-166 and IC-186 vs 2K Polyurethane DTM

- Lower cost in use – higher solids system vs standard 2K PU
- Lower VOC formulations
- Faster dry times
- Good QUV resistance
- No catalyst needed

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Polycarbamide Formulations vs Traditional Polyaspartics DTM

Polycarbamide formulations could be prepared to meet physical properties of Polyaspartics DTM

Coatings physical properties	Polyaspartic A	Polyaspartic B	IC-186	IC-186/IC-166
PVC %	15	15	15	15
Volume solids %	68	68	68	68
Weight solids %	80	80	80	80
VOC (g/L)	250	250	250	250

Performance properties of Polycarbamide DTM Coatings Show Improved Solvent Resistance and Adhesion

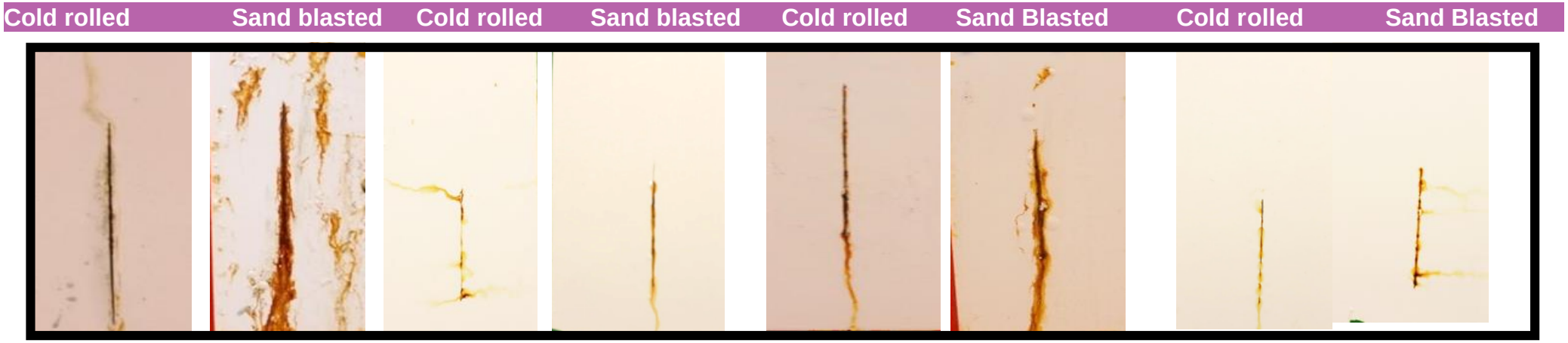
Property	Polyaspartic A	Polyaspartic B	IC-186	IC-186/IC-166
VOC at application (g/L)	250	250	250	250
Gloss, 60°	92.2	90.8	91.3	90
Water immersion (24 hr)	Pass	Pass	Pass	Pass
Tape adhesion (dry, wet)	4A, 4A	4A, 4A	5A, 5A	5A,5A
Conical Mandrel bend (%)	3.7	Pass	Pass	Pass
MEK immersion (24 hr)	One hour	4-16 hours	Pass	Pass
Toluene Immersion (24 h)	Pass	Pass	Pass	Pass
Pencil Hardness	HB	HB	2H	3H

Water Immersion, Tape adhesion, Impact , Persoz hardness, Water and solvent resistance: tested on Bondrite 952 Panels (3mils DFT) Mandrel Bend test: Treated Aluminum panel (3 mils DFT)

Improved Adhesion of Polycarbamide Coatings Provides a Better Corrosion Protection vs Traditional Polyaspartics

*Corrosion creep is on a scale of 1 to 10 where 10 does not show any creep

**Adhesion is on a scale of 1 to 10 where 10 indicates complete adhesion



Salt spray – 500h on cold rolled steel	Polyaspartic A	IC-186	Polyaspartic B	IC-166/ IC-186
Corrosion creep*	8	10	8	10
Face blisters	Few	None	Few	None
Adhesion**	7	9	7	9

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Key Advantages for Amicure® IC-166 and IC-186 DTM vs Traditional Polyaspartics

- Better corrosion protection
- Outstanding adhesion to cold rolled steel
- Outstanding impact resistance properties
- Improved solvent resistance
- Improved flexibility
- Excellent surface appearance at ambient and low temperature
- Can be formulated with zero or ≤ 250g/l VOC

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Polycarbamide Performance vs Acrylic Urethane Topcoats

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Polycarbamide Amicure® IC-166 & IC-186 Model Topcoat Formulations

	Amicure IC-186 Topcoat		Amicure IC-166 Topcoat		
Raw Materials	**Lbs**	**Gal**	**Lbs**	**Gal**	**Supplier**
Part A					
Amicure IC-166			306.1	34.5	Evonik
Amicure IC-186	306.1	34.5			Evonik
BYK 163	7.9	1.0	8.0	1.0	BYK
Tipure R 960 TiO2	341.5	10.4	341.5	10.4	Chemours
Part A Total	**664.0**	**45.4**	**655.5**	**44.6**	
Part B					
Isocyanate HDI trimer	222.9	23.7	222.9	23.7	
Methyl Amyl Ketone	206.3	30.5	206.3	30.5	Eastman
Part B Total	**425.7**	**54.2**	**425.7**	**54.2**	
Part A + Part B	**1090.2**	**100.0**	**1102.0**	**100.0**	
Formulation Properties	**Values**		**Values**		
Weight per Gallon (lb/gal)	10.9		11.0		
Non Volatile weight (lb)	80.0		80.2		
Non Volatile volume (gal)	68.6		68.0		
PVC (%)	15.3		14.0		
VOC(lbs/gal)	2.2		2.2		
VOC(g/l)	263.0		263.0		

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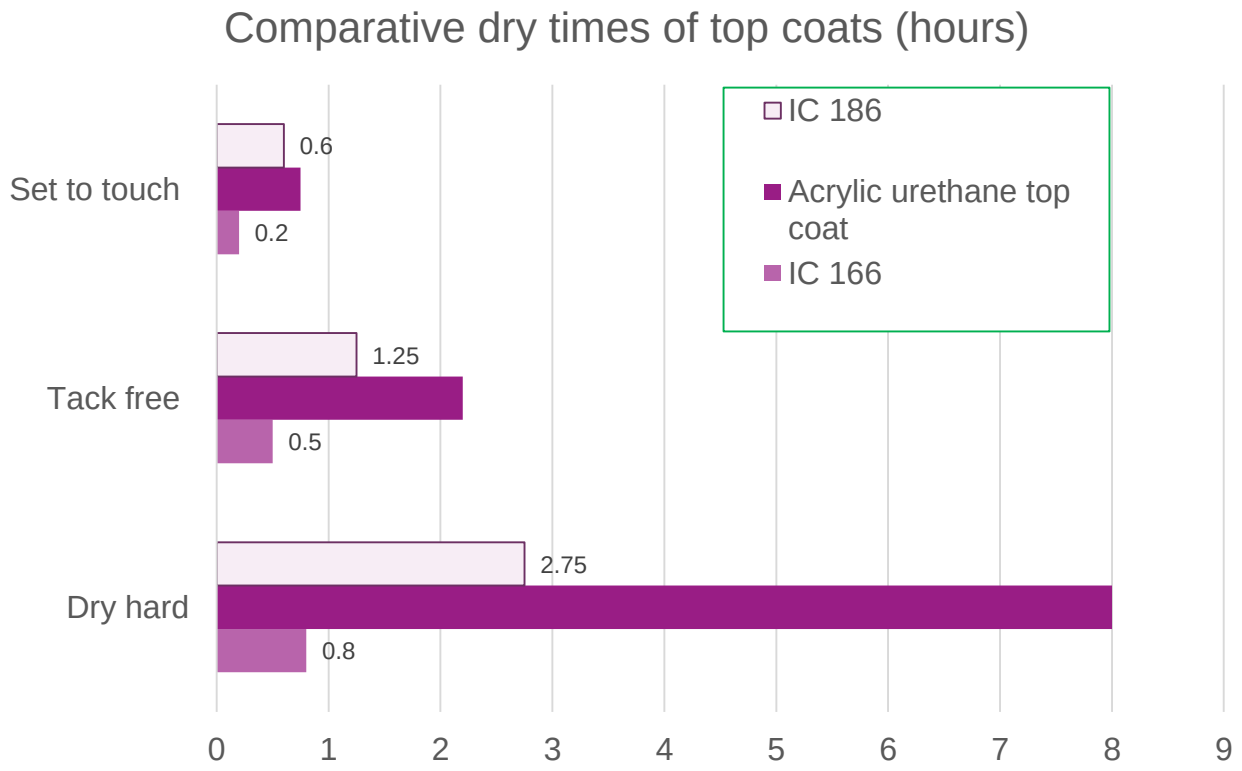
Polycarbamide Technology Provides Much Faster Return to Service Compare to Acrylic Urethane Topcoats

Coatings physical properties	IC-166	IC-186	Acrylic urethane
PVC %	15	15	15
Volume solids %	68	68	44
Weight solids %	80	80	57
VOC (g/L)	**250**	**250**	**385**

- Polycarbamide coatings provide higher Vol solids at lower VOC



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Summary

- Evonik has developed two Polycarbamide curing agents, Amicure® IC-166 & IC-186 that provide fast return to service and great surface aesthetics in both DTM and topcoat applications
- IC-166 is a faster polycarbamide that provides coatings with an ultra fast return to service
- IC-186 provides longer pot life that enables coatings to be applied using conventional spray equipment
- IC-166 & IC-186 are compatible with each other and can be mixed to provide customers with a required performance for their application
- Evonik Polycarbamide curing agents allow formulators to meet coatings market needs for improved productivity, ease of application, and long term protection of their customers' assets


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