

Force Dryer (Rapid Curing) System for Painted Pipe Spools

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Publication Date: 2026/05/19

Abstract: In industrial piping fabrication projects, coating systems applied to pipe spools often require extended ambient curing times before handling, inspection, shipment, or installation. These delays can significantly impact production schedules, logistics flow, and project milestones. To overcome such constraints, a Force Dryer (Rapid Curing) System can be employed to accelerate the curing process of painted spools through controlled hot-air circulation while maintaining coating integrity and compliance with project specifications.

This technical paper presents the objectives, the system description, the project requirement, the operating procedures, the performance benefits and risks, the quality controls and safety requirements of a containerized Force Dryer system. The system is specifically developed for rapid curing of shop-painted spools used in oil & gas facilities, petrochemical plants, and industrial construction projects.

How to Cite: Khalid H. Alwayli; Euitaek Jung; Prasanta Dey (2026) Force Dryer (Rapid Curing) System for Painted Pipe Spools. *International Journal of Innovative Science and Research Technology*, 11(4), 4889-4894.

<https://doi.org/10.38124/ijisrt/26apr2252>

I. INTRODUCTION

Protective coating systems are essential for corrosion prevention and asset life extension of steel piping spools. However, most liquid-applied coatings such as epoxy, polyurethane, zinc-rich primers, and phenolic systems require curing time ranging from several hours to multiple days under ambient conditions.

Project schedules often demand faster throughput. Delays caused by slow curing may result in Congestion in paint yards, Delayed hydrotest and dispatch, Increased handling damage risk, Reduced fabrication productivity and Late material delivery to site A Force Dryer (Rapid Curing) System resolves these issues by providing a controlled high-temperature airflow to accelerate polymer crosslinking and solvent evaporation.

II. OBJECTIVE OF THE FORCE DRYER SYSTEM

The primary purpose of the force dryer to shorten curing time of painted spools, to maintain coating quality and adhesion, to enable faster handling and transportation, to improve fabrication yard productivity and comply with Project Coating Specifications and coating manufacturer requirements

As stated in the following System Description, curing must fully comply with project specification and coating manufacturer requirements.

III. SYSTEM DESCRIPTION

The force dryer is a 40-foot containerized hot-air curing chamber equipped with the following key components.

- Far-Infrared Radiation Panels ensure uniform heat distribution, enabling consistent drying across coated surfaces.
- Control System is a user-friendly interface allowing precise adjustments of temperature, time, and power output.

- Ventilation and Air Circulation Unit efficiently expels harmful gases and moisture generated during the drying process, ensuring a safe working environment.
- Temperature Sensors and Monitoring System provide real-time temperature detection and system status monitoring to ensure stable operation.

➤ *Functional Principle*

The system works by circulating heated air uniformly around painted spools. Controlled temperature accelerates. Solvent-Based Coatings consists of Solvent flash-off, Oxidative

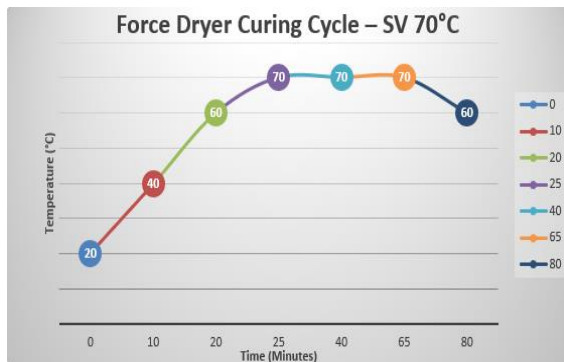
curing and film hardening. Two Component Coatings consist of Cross-linking reaction, resin hardening and final mechanical strength development.

➤ *Typical Forced Curing Temperature Profile*

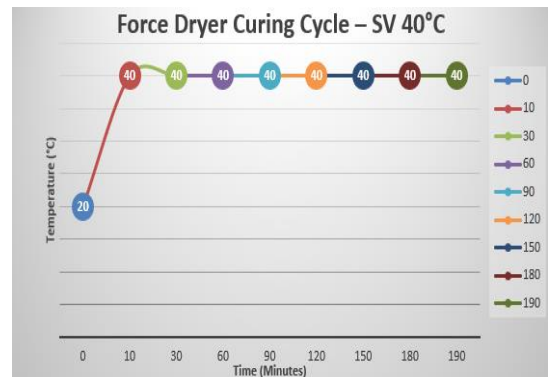
Forced curing shall be carried out using an electrically heated force dryer to accelerate curing of painted spools, in accordance with SAES-H-101V and coating manufacturer’s written approval. The curing cycle consists of Ramp-Up, Hold (Soak), and Cooling stages as shown in the approved temperature profile.

Table 1 : Temperature profile (Force Dryer Curing Cycle)

SV = 70 °C (Fast Curing)	SV = 40 °C (Extended Curing)
Initial temperature (PV): ~20 °C	Initial temperature (PV): ~20 °C
Ramp-up time: 25 minutes	Ramp-up time: 10 minutes
Hold time at 70 °C: 40 minutes	Hold time at 40 °C: 180 minutes
Cooling time: 15 minutes	Cooling time: 0 minutes
Total cycle time: 80 minutes	Total cycle time: 190 minutes



Title: Force Dryer Curing Cycle -SV 70deg C



Title: Force Dryer Curing Cycle -SV 40deg C

Notes:

- Set Value (SV) remains constant throughout curing cycle
- Present Value (PV) may fluctuate within ±5 degC
- Hold time starts only after PV reaches SV
- Controller automatically adjusts heater output to maintain SV

IV. TYPICAL COATING SYSTEMS PROCESSED

The following tables show the dryer application report of the coating manufacturer and common Saudi Aramco Approved Protective Coating Systems (APCS). These results indicate that the use of this dryer was suitable under APCS.

Table 2: Coating Manufacturer's Force Dryer Application Report

APCS No	Paint Coat	Product Name	DFT (µm)	Far-Infrared Gunning	Temp (°C)	Time (Min)		Remarks
						Heating	Cooling	
APCS 1A	Primer	GALVOSIL 15780	65	X		Not Available		Inorganic
	Intermediate	HEMPADUR MASTIC 45880/45881	100	O	70	45	15	
	Top Coat	HEMPADUR MASTIC 45880/45881	150		40	180	0	
APCS 1B	Primer	HEMPADUR HB PRIMER 17300	75	O	70	45	15	
	Intermediate	HEMPADUR MASTIC 45880/45881	100	O	70	45	15	
	Top Coat	HEMPADUR MASTIC 45880/45881	150		40	180	0	
APCS 2A/2C	Primer	HEMPADUR 85671	100	O	70	45	15	
	Intermediate	HEMPADUR 85671	100	O	70	45	15	
	Top Coat	HEMPADUR 85671	100		40	180	0	
APCS 11A	Primer	GALVOSIL 15780	65	X		Not Available		Inorganic
	Top Coat	HEMPEL'S SILICONE ALUMINIUM 56910	25	O	70	75	15	
APCS 11B	Primer	HEMPEL'S SILICONE ALUMINIUM 56910	25	O	70	45	15	
	Top Coat	HEMPEL'S SILICONE ALUMINIUM 56910	25	O	70	75	15	
APCS 11C	Primer	VERSILINE CUI 56990	150	O	70	45	45	
	Top Coat	VERSILINE CUI 56990	150	O	70	45	15	
APCS 26T	Primer	HEMPADUR MASTIC 45880/45881	150	O	70	45	15	
	Intermediate	HEMPADUR MASTIC 45880/45881	150	O	70	45	15	
	Top Coat	HEMPATHANE 55210	50	O	70	45	15	

* No defect was observed such as blisters, popping and discoloration.

Table 3: SA APCS & DFT

Paint Sys.	Surface Preparation	Coating System Information	Product	Total System DFT (μm)
APCS 1A	SSPC SP10, 1.6-2.6 mil profile (40-65 μm)	3 coat system: inorganic zinc primer and two epoxy topcoats	Inorganic Zinc Primer / Epoxy Intermediate / Epoxy Topcoat, DFT (μm): Primer = 65-100 / Intermediate and Topcoat = 105-150 per coat	275 min. – 400 max. (3 paint coats)
APCS-1B	SSPC SP10, 1.6-2.6 mil profile (40-65 μm)	3 coat system: epoxy primer and two epoxy topcoats	Epoxy Primer / Epoxy Intermediate / Epoxy Topcoat, DFT (μm): Primer = 50-100 / Intermediate and Topcoat = 110-150 per coat	275 min. – 400 max. (3 paint coats)
APCS-1D	SSPC SP10, 1.6-2.6 mil profile (40-65 μm)	3 coat system: inorganic zinc primer, epoxy intermediate coat and polyurethane topcoat	Inorganic Zinc Primer / Epoxy Intermediate / Polyurethane Topcoat, DFT (μm): Primer = 65-100 / Intermediate = 100-150 / Topcoat = 25-65	190 min. – 315 max. (3 paint coats)
APCS-1E	SSPC SP10, 1.6-2.6mil profile (40-65 μm)	3 coats of Epoxy/Polyurethane Coating System for Atmospheric Service	Epoxy Primer / Epoxy Intermediate / Polyurethane Topcoat, DFT (μm): Primer = 50-100 / Intermediate = 100-150 / Topcoat = 25-65	175 min. – 315 max. (3 paint coats)
APCS-2A	SSPC SP5, 1.6-2.6 mil profile (40-65 μm)	3 coats of immersion grade phenolic epoxy	Phenolic Epoxy Primer / Phenolic Epoxy Intermediate / Phenolic Epoxy Topcoat, DFT (μm): Primer = 95-125 / Intermediate = 90-125 / Topcoat = 90-125	275 min. – 375 max. (3 paint coats)
APCS-2C	SSPC SP5, 1.6-2.6 mil profile (40-65 μm)	3 coats of immersion grade phenolic epoxy	Phenolic Epoxy Primer / Phenolic Epoxy Intermediate / Phenolic Epoxy Topcoat, DFT (μm): Primer = 95-125 / Intermediate = 90-125 / Topcoat = 90-125	275 min. – 375 max. (3 paint coats)
APCS-11A	SSPC SP10, 1.6-2.6 mil profile (40-65 μm)	2 coat system of inorganic zinc primer	Inorganic Zinc Primer / Silicone Aluminum Topcoat, DFT (μm): Primer = 25-65 / Topcoat = 15-40	40 min. – 105 max. (2 paint coats)
APCS-11B	SSPC SP10, 1.6-2.6 mil profile (40-65 μm)	2 coat system of Heat-Resistant System: (Self-Priming)	Silicone Aluminum Primer / Silicone Aluminum Topcoat, DFT (μm): Primer = 15-40 / Topcoat = 15-40	30 min. – 80 max. (2 paint coats)
APCS-11C	SSPC SP6	2 coat system: specialty high temperature paint	System 1: Inorganic Copolymer Primer / Inorganic Copolymer Topcoat, DFT (μm): Primer = 125-150 / Topcoat = 125-150	250 min. – 300 max. (2 paint coats)
APCS-17A/B	SSPC SP10, 1.6-2.6 mil profile (40-65 μm)	1 coat system of inorganic zinc primer	Inorganic Zinc Primer (Solvent Based), DFT (μm): Primer = 65-100	65 min. – 100 max.
APCS-26	SSPC SP16, 0.8 mil profile minimum (20 μm minimum)	2 coats system of epoxy mastic	Epoxy Mastic Coating (Self-Priming), DFT (μm): each coat = 150 – 200	300 min. – 400 max.
APCS-26T (For New Construction)	SSPC SP16, 0.79 mil profile minimum (20 μm minimum)	3 coat system: epoxy mastic primer, epoxy mastic intermediate and polyurethane topcoat	Epoxy Mastic Primer & Intermediate/ Polyurethane Coating System, DFT (μm): Primer = 150-200 / Intermediate = 150-200 / Topcoat = 40-60	340 min. – 460 max.

V. OPERATING PROCEDURE

Preloading Conditions before entering dryer, Painting completed minimum 45 minutes earlier, after that surface tack-free accordingly QC need to approve and no visible defects.

Spool Loading Procedure consists of Position carrier at entrance, Lift spool using chain hoist, Place on V-rollers,

maintain minimum 300 mm spacing, Push carrier inside chamber and repeat loading sequence as per dryer capacity and approved layout.

Heating Control consists of set dryer temperature strictly as per coating manufacturer recommendation through touch screen on HMI. Typically approved operating temperature: 40 to 70 degC. Heating must be gradual to prevent Solvent entrapment,

Blistering, Wrinkling, Pinholes, and Over-skinning. Continuous monitoring of air and surface temperature shall be maintained.

➤ *Curing Cycle Follows The Following Steps*

According to the time and temperature setting above, the following three controlled phases will be conducted automatically.

- Phase 1 – Ramp Up: Increase temperature gradually from ambient to set value.
- Phase 2 – Hold / Soak: Maintain constant temperature for specified time.
- Phase 3 – Cooling: Natural cooling only. No water or forced cold air.

Record temperature and time at regular intervals on log sheet for reference

➤ *Spool Unloading/Removal Procedure*

- After cooling, open container doors and ensure safe temperature for handling.
- Pull carriers toward container entrance using internal rail system.
- Lift spools using chain hoist and place them on designated supports or transport saddles. Forklift may be used only after spool is fully clear of container and secured.
- Inspect coating surface for any transit or handling damage.

➤ *Advantages of Force Dryer*

Productivity Increase like Ambient curing may require: 8–24 hours, Rapid curing reduces this to: 1.3–3.3 hours, this can improve throughput by over 300%.

Reduced Yard Congestion like Faster spool turnover, less storage space required and better workflow. Earlier Dispatch spools become ready for Final inspection, Packing, Shipment and Site erection.

➤ *Critical Technical Risks*

Improper controlled force curing may cause the following risks. However, since all operations are automatically controlled by well-configured PLC logic with the set temperature based on coating manufacturer’s TDS, such concerns seldom occur.

Table 4: - Risk and Cause for critical technical risks

Risk	Cause
Blistering	Rapid heating
Solvent trap	Early skin formation
Loss of gloss	Excessive temperature
Poor adhesion	Incorrect cure cycle
Microcracking	Thermal shock

➤ *Quality Control Requirements*

• *Inspection After Curing Includes:*

Visual Examination to ensure No blistering, No cracking, No discoloration, No delamination. Thickness Verification: Dry Film Thickness (DFT) must remain within specified range. Also Adhesion Testing if required which contains pull-off test, tape test and holiday Testing for immersion or buried systems.

➤ *Safety Requirements*

This procedure needs to follow safety requirements which consists of proper ventilation, no solvent vapor accumulation, trained operators, temperature below flash point limits. Fire extinguishers need to be considered as per safety requirement. PPE for operators is mandatory.

➤ *Recommended Best Practices*

Process Control shall be used calibrated sensors, data logger and recorded every batch cycle. Coating Control needs to obtain written coating manufacturer approval, respect max/min recoating intervals and confirm tack-free before heating.

Mechanical Handling shall be used padded supports. Prevent metal-to-metal damage and protect flange faces and bevels

VI. CONCLUSION

The Force Dryer (Rapid Curing) system is a practical and technically sound solution for accelerating the curing of painted pipe spools in fabrication yards. When operated under controlled temperature cycles and in accordance with coating manufacturer approval, the system significantly reduces curing time while preserving coating performance.

For major EPC projects where schedule adherence is critical, this technology offers Faster production cycles, Improved logistics flow, better yard efficiency, Reduced handling delays and Compliance with industrial coating standards.

This procedure demonstrates a mature implementation suitable for high-specification oil & gas fabrication environments.

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