Form R

Reporting

of

Binder Chemicals

Used in Foundries

Fourth Edition

American Foundry Society
and
Casting Industry Suppliers Association

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INTRODUCTION

The information in this publication is provided to help foundries more accurately report on the uses and releases of those binder system chemicals which are reportable under SARA Title III Section 313 and 40 CFR Part 372. We have strived to include the most comprehensive listing of chemicals that are published on the 40 Part 372.65 list. This report utilizes EPA Form R (EPA Form 9250-1 and subsequent revisions).

The contents have been organized into four sections. The first section explains related binder systems and foundry terms. The second section is an example problem illustrating how the information in this publication can be used to estimate releases of binder chemicals. The third section consists of tables for the many different generic binder systems for each chemical listing the percentage which reacts during the curing/reaction and no longer exists as that chemical. Percentages are also listed for the amounts of each chemical, which either is released during the core/mold making process or the chemical remaining in the core/mold after curing before it is exposed to the molten metal. **No information is given on what happens to those chemicals remaining in the mold/core once they are pyrolyzed by the molten metal.** Section four lists common categories of binders and their corresponding trade names.

The information in this document was provided by the Environmental Committee of the Casting Industry Suppliers Association (CISA), compiled, and published by the American Foundry Society (AFS).

The emission factors for phenolic urethane nobake and phenolic urethane coldbox systems utilize data compiled by the Ohio Cast Metals Association for the Ohio EPA.

SECTION 1: TERMS

Generic Name of Core/Mold Binder

	% **Reacted**	% **Released**	% **Remaining in Mold/Core**

Part I
Chemical Name (CAS #)

Chemical Name (CAS #)

Part II
Chemical Name (CAS #)

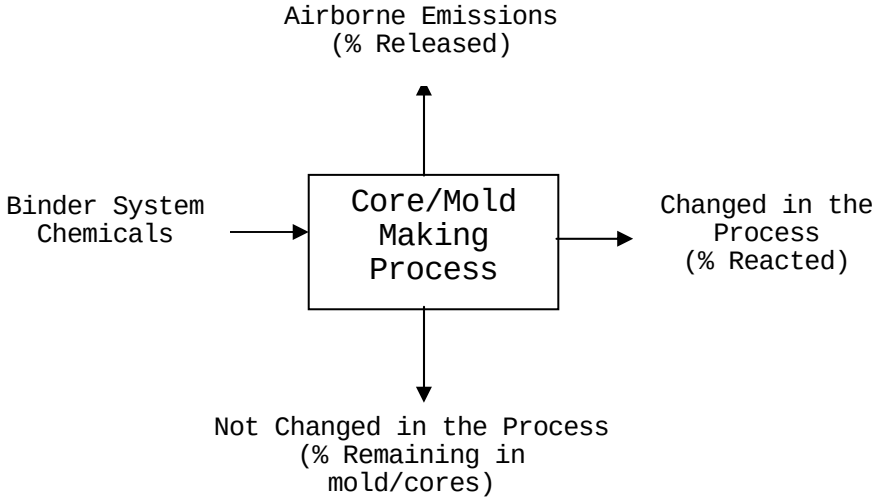
Chemical Name (CAS #)

Terms
% Reacted—the amount of this chemical which reacts during the curing process and no longer exists as this chemical after curing.

% Released—the amount of this chemical, which during the mold/core making process is released to the environment.

% Remaining in the Mold/Core—the amount of this chemical, after curing/reacting, that remains in its original form in the finished core/mold.

SECTION 2: EXAMPLE PROBLEM



For example: A phenolic urethane coldbox binder is used to make cores, this binder consists of two components, Part I and Part II. During the course of a year, usage totals are 400,000 pounds of Part I and 325,000 pounds of Part II. The Material Safety Data Sheet (MSDS) shows that Part I consists of phenol (6%), trimethylbenzenes (2.08%), naphthalene (1.98%), xylene (0.44%), formaldehyde (0.3%), cumene (0.16%) and biphenyl (0.08%) and that Part II consists of: polymeric MDI (75%) (N120), naphthalene (4.06%), xylene (0.2%) and biphenyl (0.08%).

Since the percentages of xylene, cumene and biphenyl in Part I and the percentages of xylene and biphenyl in Part II are below the SARA diminimus level (1% for non-carcinogens and 0.1% for carcinogens) no inventory or further calculations for these chemicals from this binder are necessary.

EXAMPLE PROBLEM (cont'd.)

Inventory Calculations

(% of chemical in binder multiplied by the amount of that binder used)

Part I Chemicals

Chemical	%	Pounds Used	Pounds of Chemicals*
Phenol	6	400,000	24,000
Trimethylbenzene	2.08	400,000	8,320
Naphthalene	1.98	400,000	7,920
Formaldehyde	0.3	400,000	1,200

* = % of chemical in binder multiplied by the amount of binder used.

Part II Chemicals

Chemical	%	Pounds Used	Pounds of Chemicals
Polymeric MDI	75.0	325,000	243,750
Naphthalene	4.06	325,000	13,195

If this binder system was the only source of these chemicals then a Form R would only be needed for phenol (24,000 pounds), polymeric MDI (243,750 pounds) and naphthalene (21,115 pounds; 7,920 from Part I plus 13,195 from Part II).

The next step is to determine what has happened to these chemicals. In the coremaking process, it is known that a certain percentage of each chemical either is reacted in the process, released to the environment, or remains in the finished core/mold.

EXAMPLE PROBLEM (cont'd.)

For the Phenolic Urethane Coldbox process these percentages are:

	% **Reacted**	% **Released**	% **Remaining in Mold/Core**
Part I			
Formaldehyde	98	2	0
Phenol	98	0	2
Naphthalene	0	3.25	96.75
Part II			
Polymeric MDI	99.99	0	0.01
Naphthalene	0	3.25	96.75

The next step is to calculate how much of each chemical reacted, was released or remains in the core. This is done by multiplying the pounds of that chemical by the percentage reacted, released, or remaining in the core.

Formaldehyde

Reacted	=	(0.98 x 1,200 pounds)	= 1,176 pounds
Released	=	(0.02 x 1,200 pounds)	= 24 pounds
Remaining	=	(0 x 1,200 pounds)	= 0 pounds
Total			= 1,200 pounds

Phenol

Reacted	=	(0.98 x 24,000 pounds)	= 23,520 pounds
Released	=	(0 x 24,000 pounds)	= 0 pounds
Remaining	=	(0.02 x 24,000 pounds)	= 480 pounds
Total			= 24,000 pounds

EXAMPLE PROBLEM (cont'd.)

Polymeric MDI

Reacted	=	(0.9999 x 243,750 pounds)	=	243,726 pounds
Released	=	(0 x 243,750 pounds)	=	0 pounds
Remaining	=	(0.0001 x 243,750 pounds	=	24 pounds
Total	=		=	243,750 pounds

Naphthalene (Part I & Part II calculations combined due to identical %s)

Reacted	=	(0 x 21,ll5 pounds)	=	0 pounds
Released	=	(0.0325 x 21,115 pounds)	=	686 pounds
Remaining	=	(0.9675 x 21,115 pounds)	=	20,429 pounds
Total			=	21,115 pounds

So, for Form R reporting purposes, 1,176 pounds of formaldehyde and 23,520 pounds of phenol were consumed in the process and 243,726 pounds of polymeric MDI were consumed in the process. There was 686 pounds of naphthalene released as a fugitive airborne emission.

Still to be accounted for as possible releases are: 480 pounds of phenol, 24 pounds of polymeric MDI and 20,429 pounds of naphthalene. These are the quantities of chemicals that remain in the cores when moved to storage and/or used in the molds to make castings.

These chemicals may released from the cores prior to their use; or be thermally destroyed (pyrolyzed)/changed during pouring and cooling of the casting; or remain in the core unchanged and mixed with the molding sand at shakeout; or remain in the core butt; or remain in the core if it is discarded and not used to produce a casting; or may volatilize and recondense in the molding sand during pouring/cooling; or may volatilize and be released in the gases coming off the mold during pouring/cooling; or may volatilize and be released in the gases coming off the mold during pouring/cooling but be destroyed/changed as these gases burn.

SECTION 3: INFORMATION TABLES

Binder: Alkyd Oil

	% **Reacted**	% **Released**	% **Remaining in Mold/Core**
Resin			
Cobalt (7440-48-4)	0	0	100
Co-reactant			
Polymeric MDI (N120)	99.99	0	0.01

INFORMATION TABLES (cont'd.)

Binder: Acrylic/Epoxy/SO_2

	% **Reacted**	% **Released**	% **Remaining in Mold/Core**
Part I			
Cumene Hydroperoxide (80-15-9)	97	0	3
Cumene (98-82-8)	0	1.5	98.5

INFORMATION TABLES (cont'd.)

Binder: Furan Hotbox

	% **Reacted**	% **Released**	% **Remaining in Mold/Core**
Resin			
Formaldehyde (50-00-0)	95	5	0

INFORMATION TABLES (cont'd.)

Binder: Furan Nobake

	% **Reacted**	% **Released**	% **Remaining in Mold/Core**
Resin			
Phenol (108-95-2)	98+	0	2-
Formaldehyde (50-00-0)	98	2	0
Methyl Alcohol (67-56-1)	0	50	50
Catalyst			
Methyl Alcohol (67-56-1)	0	50	50
Sulfuric Acid (7664-93-9)	100	0	0

INFORMATION TABLES (cont'd.)

Binder: Furan/SO_2

	% **Reacted**	% **Released**	% **Remaining in Mold/Core**
Resin			
Formaldehyde (50-00-0)	98	2	0
Methyl Alcohol (67-56-1)	0	50	50
Oxidizer			
Dimethyl Phthalate (13 1-11-3)	0	50	50
Methyl Ethyl Ketone (78-93-3)	0	50	50

INFORMATION TABLES (cont'd.)

Binder: Furan Warmbox

	% **Reacted**	% **Released**	% **Remaining in Mold/Core**
Resin			
Formaldehyde (50-00-0)	95	5	0
Catalyst			
Methyl Alcohol (67-56-1)	0	100	0

INFORMATION TABLES (cont'd.)

Binder: Phenolic Baking

	% **Reacted**	% **Released**	% **Remaining in Mold/Core**
Part I			
Phenol (108-95-2)	95	0	5
Formaldehyde (50-00-0)	95	5	0

INFORMATION TABLES (cont'd.)

Binder: Phenolic Ester Nobake

	% **Reacted**	% **Released**	% **Remaining in Mold/Core**
Resin			
Formaldehyde (50-00-0)	98	2	0
Phenol (108-95-2)	98	0	2

INFORMATION TABLES (cont'd.)

Binder: Phenolic Ester Coldbox

	% **Reacted**	% **Released**	% **Remaining in Mold/Core**
Resin			
Formaldehyde (50-00-0)	98	2	0
Phenol (108-95-2)	98	0	2
Glycol Ethers(1)	0	50	50
Co-reactant			
Methanol (67-56-1)	0	50	50

(1) = Listed as Certain Glycol Ethers under (c) Chemical categories on the SARA 313 list.

INFORMATION TABLES (cont'd.)

Binder: Phenolic CO_2 Cure

	% **Reacted**	% **Released**	% **Remaining in Mold/Core**
Resin			
Glycol ether (112-34-5)	0	0.5	99.5
Glycol ether (122-99-6)	0	0.5	99.5

INFORMATION TABLES (cont'd.)

Binder: Phenolic Hotbox

	% **Reacted**	% **Released**	% **Remaining in Mold/Core**
Resin			
Formaldehyde (50-00-0)	95	5	0
Phenol (108-95-2)	95	0	5

INFORMATION TABLES (cont'd.)

Binder: Phenolic Nobake-Acid Catalyzed

	% **Reacted**	% **Released**	% **Remaining in Mold/Core**
Resin			
Phenol (108-95-2)	98	0	2
Formaldehyde (50-00-0)	98	2	0
Methyl Alcohol (67-56-1)	0	50	50
Acid			
Methyl Alcohol (67-56-1)	0	50	50
Sulfuric Acid (7664-93-9)	100	0	0

INFORMATION TABLES (cont'd.)

Binder: Phenolic Novolac Flake—Hot Coating Operations

	% **Reacted**	% **Released**	% **Remaining in Mold/Core**
Phenolic Resin			
Phenol (108-95-2)	95	0	5

Note: The coating operation has different emissions from curing resin-coated sand. Foundries using precoated sand would not have these emissions.

INFORMATION TABLES (cont'd.)

Binder: Phenolic Novolac Liquid—Warm-Coating Operations

	% **Reacted**	% **Released**	% **Remaining in Mold/Core**
Part I			
Phenol (108-95-2)	0	20	80
Formaldehyde (50-00-0)	95	5	0
Methanol (67-56-1)	0	100	0

INFORMATION TABLES (cont'd.)

Binder: Phenolic Novolac Flake—Resin-Coated Sand

	% **Reacted**	% **Released**	% **Remaining in Mold/Core**
Phenolic Resin			
Phenol (108-95-2)	99	0	1
Catalyst			
Ammonia[(1)]	50	50	0

(1) Ammonia is generated as a breakdown product from the hexamethylenetetramine (hexa). As the hexa breaks down, forty percent is converted to ammonia. The percentages listed are for the ammonia generated from the hexa.

These are the emissions from resin coated sand during the core/mold making operation.

INFORMATION TABLES (cont'd.)

Binder: Phenolic Urethane Nobake

	% **Reacted**	% **Released**	% **Remaining in Mold/Core**
Part I			
Phenol (108-95-2)	98	0	2
Formaldehyde (50-00-0)	98	2	0
Naphthalene (91-20-3)	0	5.85	94.15
1,2,4 Trimethylbenzene (95-63-6)	0	5.85	94.15
Cumene (98-82-8)	0	5.85	94.15
Xylene (1330-20-7)	0	5.85	94.15
Part II			
Polymeric MDI (N120)	99.99	0	0.01
Naphthalene (91-20-3)	0	5.85	94.15
1,2,4 Trimethylbenzene (95-63-6)	0	5.85	94.15
Cumene (98-82-8)	0	5.85	94.15
Xylene (1330-20-7)	0	5.85	94.15

INFORMATION TABLES (cont'd.)

Binder: Phenolic Urethane Coldbox

	% **Reacted**	% **Released**	% **Remaining in Mold/Core**
Part I			
Formaldehyde (50-00-0)	98	2	0
Phenol (108-95-2)	98	0	2
Xylene (1330-20-7)	0	3.25	96.75
Cumene (98-82-8)	0	3.25	96.75
Naphthalene (91-20-3)	0	3.25	96.75
1,2,4 Trimethylbenzene (95-63-6)	0	3.25	96.75
Part II			
Polymeric MDI (N120)	99.99	0	0.01
Naphthalene (91-20-3)	0	3.25	96.75
Xylene (1330-20-7)	0	3.25	96.75
Biphenyl (92-52-4)	0	3.25	96.75

INFORMATION TABLES (cont'd.)

Binder: Urea Formaldehyde

	% **Reacted**	% **Released**	% **Remaining in Mold/Core**
Part I			
Formaldehyde (50-00-0)	98	2	0

SECTION 4: TRADE NAMES AND CATEGORIES

Alkyd-Isocyanate Binder	**Alkast®**
	Alkyd-Set®
	Deep Set®
	Linocure®
	Resyd®
	Uniset®
Acrylic-Epoxy SO_2 Coldbox Binder	**Isoset®**
	Rutaphen®
	Uniset®
Furan SO_2 Coldbox Binder	**InstaDraw®**
Furan Nobake Binder	**AD Bond®**
	Airkure®
	Chem-Rez®
	Dry Set®
	Durakast®
	Enviroset®
	Furecol®
	Furfaset®
	KemCast® 1500-2500
	Magnaset®
	Pacset®
	Resital®
Furan Warmbox Binder	**Chem-Rez®**
	Envirotherm®
	Warmset®
Ester-Cured Phenolic Coldbox and Nobake Binders	**AlpHaset®-Nobake**
	Betaset®-Coldbox
	Estabond®
	KemCast ®3000-Nobake
	Novacure®
	Novaset®
	Phenoset®-Nobake or Coldbox
	Ram-Set®-Nobake
Phenolic CO_2	**Ecolotec®**
Phenolic Hotbox Binder	**Chem-Rez®**

Phenolic Nobake Binder	**Chem-Rez®**
	Enviroset®
	KemCast® 1000
	Phenkast®
	Phenoset®
Phenolic Novolac/Coated Sand	**Excell®**
	Faskure®
	Loni®
	Resi-Flake®
	Shake Free®
	Sigma Sand®
	Signature Series®
	Super F®
	Unikote®
Phenolic Urethane Nobake Binder	**KemCast® 100**
	Novathane®
	Pepset®
	Rapidur®
	Sigmaset®
	Techniset®
	Trikast®
	Uniset®
Phenolic Urethane Coldbox Binder	**Instrakast®**
	Isocure®
	Rapidcure®
	Sigma Cure®
	Technikure®
	Unicure®

SECTION 5: RELATED READING

AFS Environmental, Health and Safety Publications:

- ***Metalcasting Ergonomics, 2nd Edition*—compiled by the AFS Environmental, Health & Safety Committee, 10-Q, this edition was designed to give you a basic view of ergonomic principles and ideas that will help you set up an effective ergonomics program within your facility. (EC0400)**

- ***Managing the Foundry Indoor Air Environment*—this book was prepared under the direction of the AFS Safety and Health Committee (10-Q) to provide foundries with updated information necessary to improve environmental conditions within their facilities. (EC0201)**

- ***Control of Lead Exposure in Foundries*—this manual was prepared under the direction of the AFS Safety and Health Committee (10-Q) to provide foundries with the information necessary control potential lead hazards. This book combines experiences and studies on how to control lead contamination based on years of learning. Six foundries volunteered their experiences and insights are featured. (EC0500)**

- ***AFS Casting Alloy Material Safety Data Sheets (MSDS)*—Casting alloy MSDSs meet the requirements of 40 CFR 372.45, [Subpart C "Supplier Notification Requirements" Section 313 of the Emergency Planning and Community Right to Know Act (EPCRA) that mandates suppliers inform their customers of the presence of toxic chemicals in mixtures and potential reporting obligations under EPCRA. These MSDSs are designed to meet both this EPA notification as well as OSHA Hazard Communication Standard Requirements. MSDS sheets are available for ferrous and nonferrous alloys, visit our e-store for specific alloy item numbers.**

- **To place an order or to view a complete catalog of our publications, visit our e-store at: www.afsinc.org/estore**

SECTION 5: RELATED READING (cont'd.)

Other AFS Publications:

- ***AFS Metalcasting Dictionary*—this handy reference contains over 200 pages of metalcasting terms and information in a convenient 6 x 9 size. This edition is completely updated to include extensive coverage of industry terminology and the latest environmental, health and safety terms that are critical in today's metalcasting industry. The two-column format and clear concise type make it easy to search for information. (GM0403)**

- ***Mold and Core Test Handbook, 3rd Edition*—this handbook is intended as a guideline for the performance of testing procedures for foundry sands and related materials in accordance with AFS Standards and Recommendations. It contains 118 sand-testing procedures that describe the latest methods for foundry sands. (GM0004)**

- ***Principles of Sand Control*—the AFS Green Sand Committee 4-M has produced a book that truly covers all aspects of sand control, from defining types of sand, use of water as an additive, characteristics of sand-clay water mixtures, molding sand preparation and mold making process, reused sand and sand reclamation. (GM0402)**

- ***Green Sand Additives, 2nd Edition*—a guide to proper additive use in green sand mixtures. Includes are the effects of proper and improper use of additives, listing indicative tests and typical observations. Extensive bibliography, additive trade names, additive manufacturers, appendix, glossary and index (GM2000)**

- ***Mold and Core Coatings Manual, 2nd Edition*—prepared by the Mold-Metal Interface Reactions Committee of the AFS Molding Methods & Materials Division 4, this revised manual introduces the basic concepts of refractory coatings for foundry applications.(GM0002)**

- ***Chemically Bonded Cores & Molds*—a true how-to documentation of operationally useful data pertaining to all known chemical binder systems that can be successfully used in the processing of cores and molds for casting production.(GM8604)**

- ***Casting Defects Handbook*—this manual was specifically designed for in-plant use by quality assurance and other personnel. It covers the diagnosis and correction phases of quality control for rejected castings or for castings requiring repair, grinding or cleaning. (GM7204)**

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