



UNIVERSITAS INDONESIA

**PENGARUH PERBEDAAN PIGMEN DAN *BINDER* PADA
ORGANIC COATING TERHADAP KETAHANAN KOROSI
DAN DAYA LEKAT PELAPISAN YANG DIAPLIKASIKAN
PADA PELAT BAJA KARBON RENDAH**

SKRIPSI

**FERDYANO FINANDA
0606074861**

**FAKULTAS TEKNIK
PROGRAM STUDI TEKNIK METALURGI DAN MATERIAL
DEPOK
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Diajukan sebagai salah satu syarat untuk memperoleh gelar Sarjana Teknik

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PROGRAM STUDI TEKNIK METALURGI DAN MATERIAL
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HALAMAN PERNYATAAN ORISINALITAS

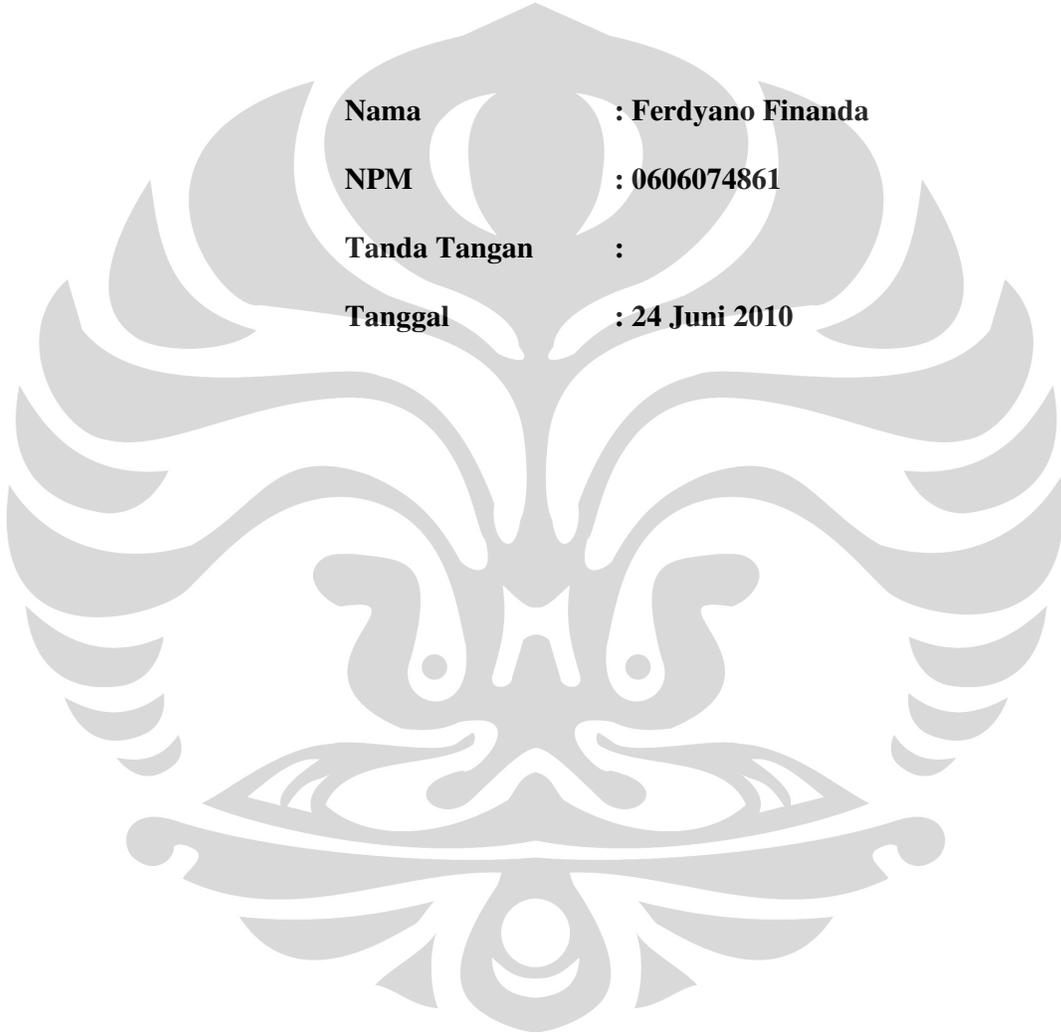
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Tanda Tangan :

Tanggal : 24 Juni 2010



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Judul Skripsi : Pengaruh Perbedaan Pigmen dan *Binder* Pada *Organic Coating* Terhadap Ketahanan Korosi dan Daya Lekat Pelapisan yang Diaplikasikan Pada Substrat Baja Karbon Rendah

Telah berhasil dipertahankan di hadapan Dewan Penguji dan diterima sebagai bagian persyaratan yang diperlukan untuk memperoleh gelar Sarjana Teknik pada Program Studi Teknik Metalurgi dan Material Fakultas Teknik, Universitas Indonesia

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Tanggal : Juni 2010

KATA PENGANTAR

Puji syukur saya panjatkan kepada Allah SWT, karena hanya atas rahmat dan karunia-Nya saya dapat menyelesaikan skripsi ini. Penulisan skripsi ini dilakukan dalam rangka memenuhi salah satu syarat untuk mencapai gelar Sarjana Teknik Program Studi Metalurgi & Material Fakultas Teknik Universitas Indonesia. Skripsi ini saya persembahkan kepada kedua orangtua, Faisal Jazid dan Naniek Koenhartati, kakak saya Fanny dan Fenno, serta Alin atas do'a, kasih sayang serta dukungannya sehingga saya dapat menyelesaikan skripsi ini. Selain itu, saya menyadari bahwa tanpa bantuan dan bimbingan dari berbagai pihak sangatlah sulit bagi saya untuk menyelesaikan skripsi ini. Oleh karena itu, saya mengucapkan terima kasih kepada:

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Depok, Juni 2010

Penulis

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Ketahanan Korosi dan Daya Lekat Pelapisan yang Diaplikasikan Pada
Substrat Baja Karbon Rendah**

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ABSTRAK

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Judul : Pengaruh Perbedaan Pigmen dan *Binder* Pada *Organic Coating* Terhadap Ketahanan Korosi dan Daya Lekat Pelapisan yang Diaplikasikan Pada Substrat Baja Karbon Rendah

Salah satu cara yang paling umum dan mudah untuk menghindari dan mengurangi terjadinya korosi pada baja karbon rendah adalah dengan cara pelapisan. Namun, seringkali terjadi kegagalan pada pelapisan akibat daya lekat cat yang kurang baik serta pigmen dan pengikat yang tidak tepat. Penelitian ini bertujuan untuk mengetahui pengaruh perbedaan pigmen dan pengikat terhadap ketahanan korosi dan daya lekat pelapisan pada substrat baja karbon rendah. Untuk menganalisa ketahanan korosinya maka metode yang dilakukan yaitu uji sembur kabut garam dan untuk daya lekat dilakukan pengujian adhesi. Untuk mengetahui tingkat ketahanan korosi dan daya lekat, maka material benda uji akan dilapisi dengan *zinc-rich* epoksi, *zinc silicate*, dan epoksi. Hasil yang didapat yaitu peringkat ketahanan korosi adalah 9 atau sangat baik untuk semua sampel. Kemudian dengan penggabungan antara pigmen *zinc* dan pengikat epoksi, menghasilkan cat dengan daya lekat yang paling baik serta penambahan kelebaran yang paling rendah.

Kata kunci:

Korosi, *coating*, adhesi, pigmen, *binder*, epoksi, *zinc-rich* epoksi, *zinc silicate*.

ABSTRACT

Name : Ferdyano Finanda
Study Program : Metalurgy and Materials Engineering
Title : The Effect of Pigmen and Binder Difference in Coating to Corrosion Resistance and Its Adhesion Level which Applied in Low Carbon Steel

The most common and easy way to avoid dan reduce the corrosion rate of low carbon steel is coating. But failures often happened due to insufficient coating adhesion and inappropriate pigmen and binder. This study aimed to understand the effect of pigmen and binder difference in coating to corrosion resistance and its adhesion level which applied in low carbon steel. The low carbon steel material which coated by zinc-rich epoxy, zinc silicate and epoxy will be tested in salt spray machine and adhesion test to analyse the corrosion resistance and the adhesion level. The result shows that corrosion resistance rating's is 9 which is very good for every sample. More specifically, the combining of pigmen zinc and binder epoxy produce coating with good adhesion and low mean creepage from scribe.

Keywords :

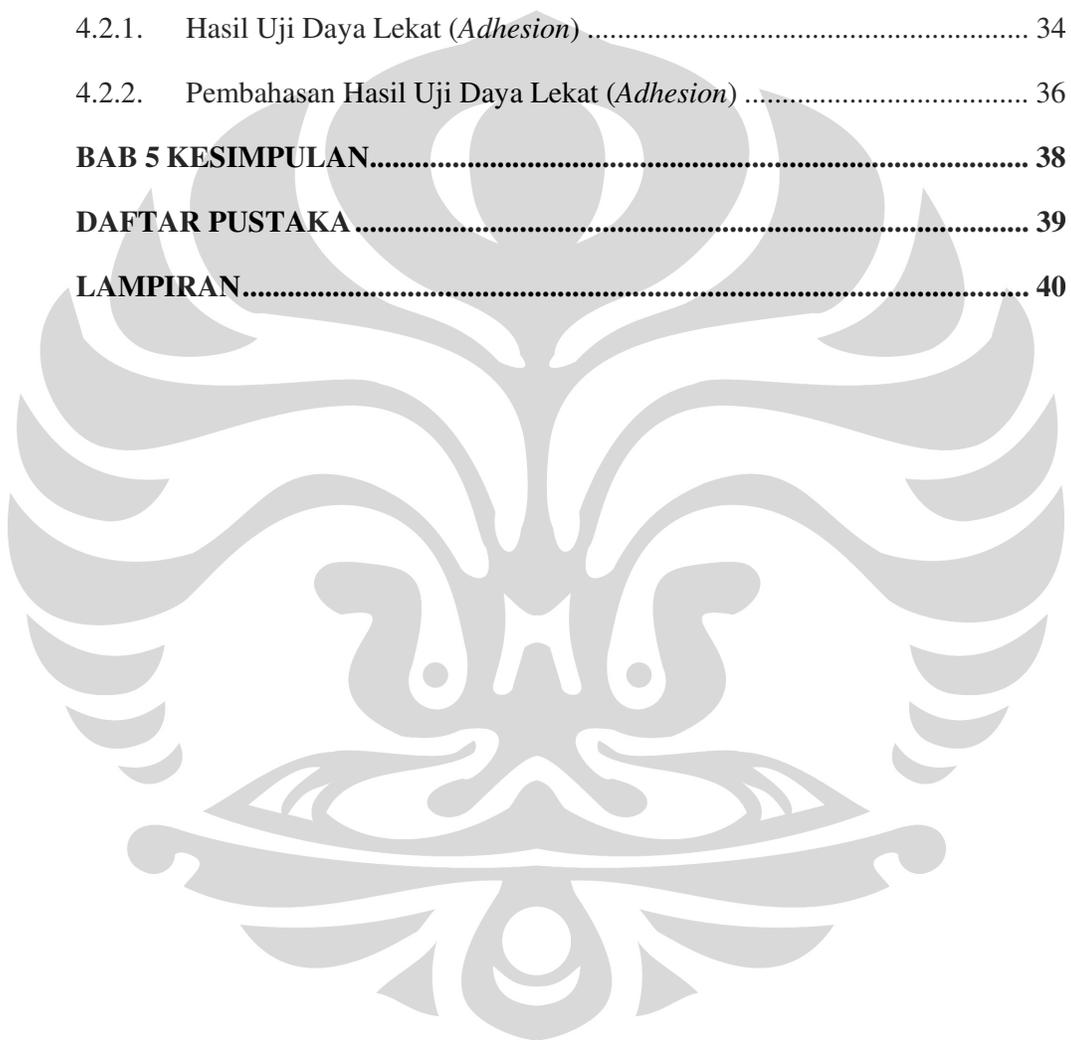
Corrosion, coating, adhesion, pigmen, binder, epoxy, zinc-rich epoxy, zinc silicate.

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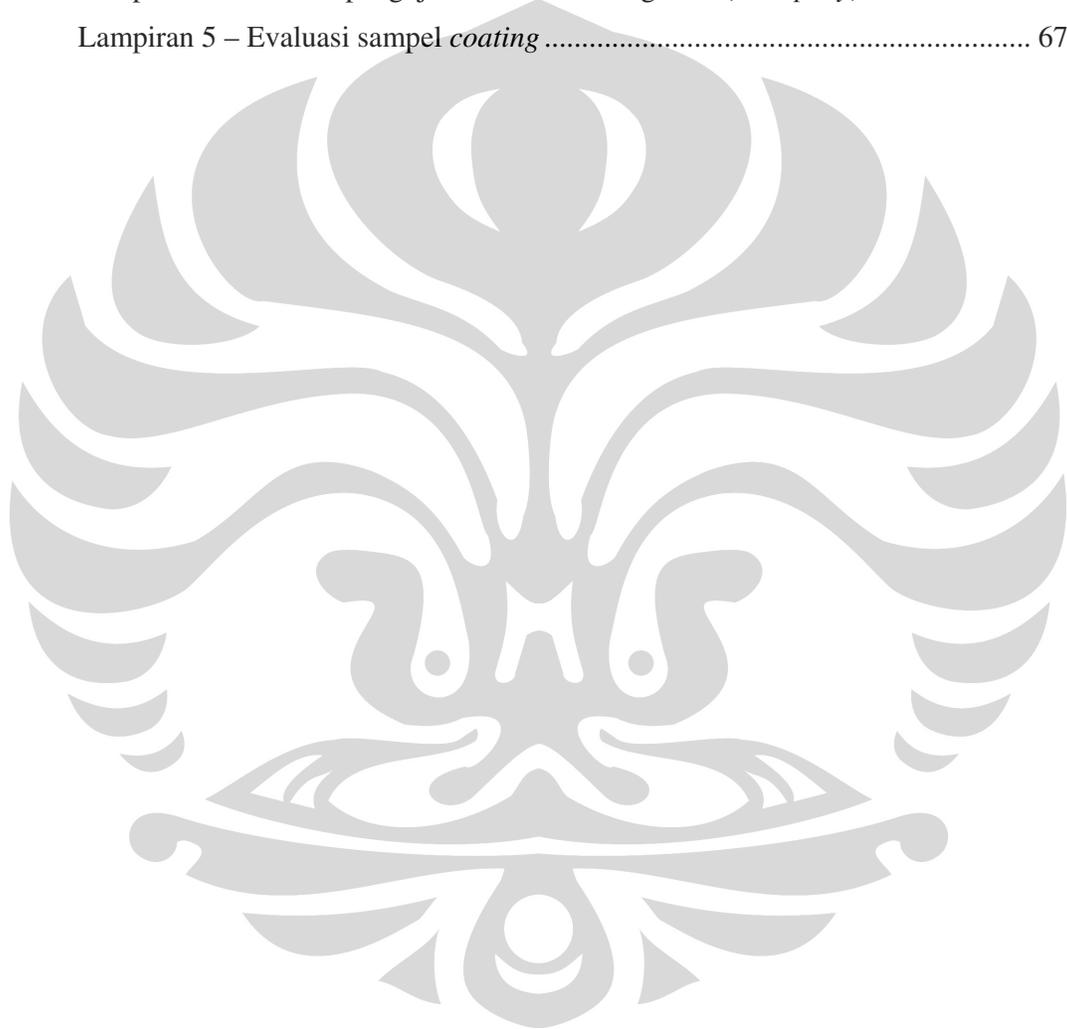
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BAB 1

PENDAHULUAN

1.1. Latar Belakang Penelitian

Korosi sangat merugikan baik dari segi biaya maupun segi keamanan. Miliaran dolar setiap tahun dihabiskan untuk penggantian struktur berkarat, mesin, dan komponen, termasuk atap logam, tabung kondensor, pipa, dan banyak peralatan lainnya. Selain biaya penggantian yang berhubungan dengan pemeliharaan pencegahan korosi, inspeksi, dan perawatan, dan juga perlindungan katodik struktur dan pipa. Biaya tidak langsung hasil korosi dari penghentian proses produksi pabrik, hilangnya efisiensi, dan kontaminasi produk[1]. Meskipun biaya penggantian alat yang sebenarnya mungkin tidak tinggi, kehilangan produksi yang dihasilkan dari kebutuhan untuk menutup operasi untuk memungkinkan penggantian bisa berjumlah ratusan dolar per jam. Ketika sebuah tangki terjadi kebocoran, nilai produksi akan berkurang atau hilang. Selain itu, kontaminasi yang dihasilkan dari alat yang bocor, membutuhkan pembersihan, dan ini bisa sangat mahal. Bila terjadi korosi, produk korosi terbentuk, akan mengakibatkan aliran pipa berkurang dan juga efisiensi, hal ini akan mengurangi panas transfer dalam penukar panas. Kedua kondisi akan menaikkan biaya operasional. Produk korosi juga dapat merugikan kualitas produk ditangani, sehingga perlu untuk membuang bahan yang berharga[2].

Selama revolusi industri, terutama dalam industri proses kimia, masalah korosi menjadi lebih penting. Untuk menanggulangi masalah ini, berbagai paduan logam dihasilkan untuk menahan serangan kimia. Sejak saat itu segudang bahan sintesis telah dikembangkan untuk memberikan perlawanan terhadap serangan korosi yang agresif[3].

Banyak paduan telah dikembangkan untuk melawan korosi, namun penggunaan bahan-bahan tersebut mungkin tidak praktis dari sudut pandang biaya, dan aplikasi spesifik. Menggunakan cat atau bahan pelapis lainnya, bahan yang lebih murah, yang memiliki syarat sifat fisik dan mekanik dapat digunakan, meskipun mereka tidak memiliki ketahanan terhadap korosi yang diperlukan. Struktur baja dapat dilindungi oleh aplikasi dari cat yang sesuai sistem. Sangat penting untuk memilih sistem cat yang tepat untuk aplikasi tertentu. Sama seperti paduan logam berbeda dalam perlawanan mereka terhadap korosi dari berbagai *corrodents*, begitu juga sistem cat serta sistem pelapis lainnya. Dengan menerapkan suatu pelapisan yang tepat, logam dasar dengan sifat mekanik yang baik dapat dimanfaatkan dengan adanya pelapisan yang tepat sehingga memberikan perlindungan terhadap korosi. Di lain waktu, pelapisan dapat diterapkan untuk tujuan dekoratif.

1.2. Tujuan Penelitian

Tujuan dari penelitian ini adalah sebagai berikut:

1. Mengetahui pengaruh perbedaan pelapis terhadap ketahanan korosi pelapisan dengan menggunakan *organic coating* dengan pigmen dan pengikat yang berbeda yang diaplikasikan pada pelat baja karbon rendah.
2. Mengetahui pengaruh perbedaan pelapis terhadap daya lekat pelapisan dengan menggunakan *organic coating* dengan pigmen dan pengikat yang berbeda yang diaplikasikan pada pelat baja karbon rendah.

1.3. Ruang Lingkup Penelitian

Batasan penelitian ini adalah:

1. Bahan baku yang digunakan dalam penelitian ini adalah sebagai berikut:
 - a. Material substrat baja karbon rendah (SCPD)
 - b. Material pelapis adalah *organic coating*, yaitu epoksi, *zinc silicate*, dan *zinc-rich* epoksi.
2. Ketebalan lapisan cat masing-masing rata-rata adalah 100 μm .
3. Preparasi permukaan substrat dilakukan sesuai ISO 8501-1 2007 (Sa 1)

4. Aplikasi pelapisan dilakukan dengan *airless spray* dan sesuai dengan *PDS* cat.
5. Pengujian yang dilakukan adalah sebagai berikut:
 - a. Pengujian sembur kabut garam (*salt spray*) sesuai ASTM B117-03 dan evaluasi terhadap hasil uji *salt spray* cat sesuai ASTM D1654.
 - b. Pengujian daya lekat (*adhesion test*) sesuai ASTM D4541-02.

1.4. Sistematikan Penulisan

Skripsi ini di susun menjadi lima bab utama yaitu pendahuluan, tinjauan literatur, metodologi penelitian, hasil dan pembahasan, dan kesimpulan.

Bab 1 Pendahuluan, berisi mengenai latar belakang penelitian, tujuan penelitian, ruang lingkup penelitian, dan sistematika penulisan.

Bab 2 Tinjauan Literatur, berisi dasar teori yang terkait, diantaranya pengetahuan umum tentang cat, proses persiapan permukaan dan kegagalan cat.

Bab 3 Metodologi Penelitian, berisi diagram alir penelitian, peralatan dan bahan-bahan yang digunakan dalam penelitian, prosedur penelitian, dan prosedur pengujian yang dilakukan.

Bab 4 Hasil dan Pembahasan, berisi pengolahan data yang di dapat dari hasil pengujian yang telah dilakukan, baik berupa angka, gambar, maupun grafik serta pembahasan mengenai hasil pengujian dan membandingkannya dengan teori serta hasil penelitian sebelumnya.

Bab 5 Kesimpulan berisi kesimpulan dari hasil penelitian yang telah dilakukan.

BAB 2

TINJAUAN LITERATUR

2.1. Pelapis (*Coating*)

2.1.1. Definisi Pelapis (*Coating*)

Pelapis (*coating*) atau biasa disebut cat adalah produk yang dapat berbentuk serbuk ataupun cair, yang terkandung di dalamnya suatu pigmen, di mana ketika diaplikasikan pada suatu substrat akan membentuk suatu lapisan film yang berfungsi baik untuk melindungi, dekorasi maupun untuk meningkatkan sifat tertentu[6].

2.1.2. Jenis – Jenis Pelapis (*Coating*)

2.1.2.1. *Metallic Coating*

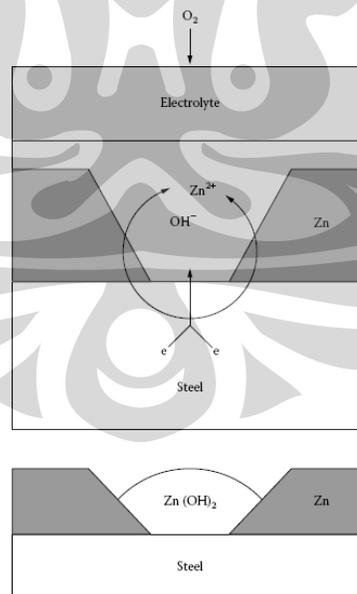
Metallic coating adalah material pelapis yang menyediakan lapisan yang dapat merubah sifat dari substratnya dan dimana logam itu diaplikasikan. Substrat dan *metallic coating* akan membentuk material komposit yang membentuk sifat yang berbeda dengan sebelumnya. Pelapis ini akan membentuk daya tahan, lapisan tahan korosi, dan kemampuan menahan beban yang lebih baik[7]. *Metallic coating* dapat diaplikasikan dengan cara *spraying*, *electroplating*, *hot dipping*, dan *chemical vapor deposition*. Metode pengaplikasian ini tergantung dari material pelapis yang akan digunakan. Beberapa *coating* yang penting adalah zinc, aluminium, cadmium, nikel, dan kromium. Untuk lebih jelasnya dapat dilihat pada Tabel 2.1. *Metallic coating* dapat diaplikasikan dengan cara *spraying*, *electroplating*, *hot dipping*, dan *chemical vapor deposition*. Metode pengaplikasian ini tergantung dari material pelapis yang akan digunakan.

Tabel 2. 1. Tipe – tipe pelapis logam serta kegunaannya

Roberge, Pierre R, *Handbook of Corrosion Engineering*, McGraw-Hill, Inc, Amerika Serikat, 2000.

Type coating	General qualities
Aluminum	Highly resistant to heat, hot water, and corrosive gases; excellent heat distribution and reflection
Babbitt	Excellent bearing wearability
Brass	Machines well, takes a good finish
Bronze	Excellent wear resistance; exceptional machinability; dense coatings (especially Al, bronze)
Copper	High heat and electrical conductivity
Iron	Excellent machining qualities
Lead	Good corrosion protection, fast, deposits and dense coatings
Molybdenum (molybond)	Self-bonding for steel surface preparation
Monel	Excellent machining qualities; highly resistant to corrosion
Nickel	Good machine finishing; excellent corrosion protection
Nickel-chrome	High-temperature applications
Steel	Hard finishes, good machinability
Chrome steel (tufton)	Bright, hard finish, highly resistant to wear
Stainless	Excellent corrosion protection and superior wearability
Tin	High purity for food applications
Zinc	Superior corrosion resistance and bonding qualities

Pada dasarnya mekanisme perlindungan pada material substrat dipengaruhi oleh proteksi katodik dengan mekanisme anoda korban, hal ini diilustrasikan pada Gambar 2.1, yaitu dengan material pelapis dengan logam seng.

**Gambar 2. 1.** Skema ilustrasi *sacrificial coating* [2]

Schweitzer, Philip, *Paint and Coatings*, Taylor and Francis Group, Amerika Serikat, 2006.

2.1.2.2. Inorganic Coating

Inorganic coating lebih dahulu digunakan dibanding *organic coating*, meskipun jenisnya sedikit, tetapi lebih mudah digunakan. Jenis dari *inorganic coating* yang sering digunakan adalah *sulfur mortar* dan *silicate mortar*. Kedua jenis ini juga disebut sebagai *acid-proof mortar* karena penggunaannya terbatas hingga pH 7, tidak untuk pengaplikasian dengan pH diatas 7, atau keadaan basa [1]. Kelebihan dari *sulfur mortar* adalah sebagai berikut:

- Tahan terhadap oksidasi dan keadaan asam
- Mudah untuk digunakan
- Tahan terhadap *thermal shock*
- Ekonomis
- Umur pakai yang tidak terbatas

Sedangkan *silicate mortar* memiliki ketahanan yang sangat baik terhadap asam yang terkonsentrasi, seperti yang ditunjukkan pada Tabel 2.2.

Tabel 2. 2. Rekomendasi penggunaan *silicate mortar*
Schweitzer, Philip, *Corrosion of Lining and Coating*, Taylor and Francis Group, Amerika Serikat, 2007.

Medium, RT	100% Silica
Acetic acid, to 10%	R
Aqua regia	N
Cadmium salts	R
Chromic acid, to 20%	R
Gold cyanide	R
Hydrochloric acid	R
Hydrofluoric acid	N
Iron salts	R
Magnesium salts	R
Methyl ethyl ketone	N
Mineral spirits	N
Nickel salts	R
Nitric acid, to 40%	R
Nitric/hydrofluoric acid	R
Phosphoric acid	R
Silver nitrate	R
Sodium hydroxide	N
Sodium salts	R
Sulfuric acid, 80%	R
Toluene	N
Trichloroethylene	N
Zinc, salts	R

RT, room temperature; R, recommended; N, not recommended.

2.1.2.3. Organic Coating

Organic coating merupakan penghalang organik tipis antara material dan lingkungannya. Cat (paint), yang terdiri dari *binder* (pengikat), pigmen, aditif, dan *solvent* (pelarut), merupakan zat lapis organik yang sering digunakan untuk proteksi korosi. Tingkatan proteksi dari pelapisan organik tergantung pada system keseluruhan dari pelapisan yang terdiri dari jenis lapisan, substrat logam, dan preparasi permukaan[2]. Terdapat beberapa jenis *organic coating*, diantaranya adalah epoksi, *furan*, *phenolics*, polyester, dan *vinyl ester*. Kelebihan *organic coating* dibanding *coating* yang lain adalah ketahanannya pada lingkungan yang beragam, tidak hanya pada keadaan tertentu saja seperti *inorganic coating* yang hanya tahan terhadap keadaan asam saja, Seperti yang ditunjukkan pada Tabel 2.3 dibawah ini.

Tabel 2. 3 Perbandingan ketahanan kimia *organic coating*

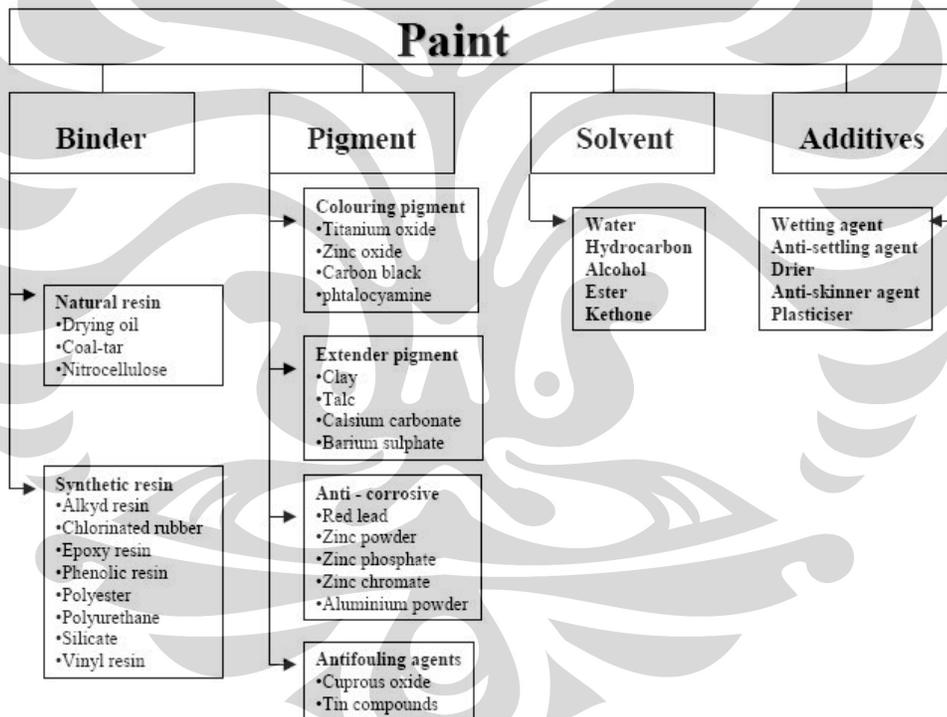
Schweitzer, Philip, *Corrosion of Lining and Coating*, Taylor and Francis Group, Amerika Serikat, 2007.

Medium, RT	1			2		3	
	A	B	C	D	E	F	G
Acetic acid, to 10%	R	R	R	R	R	R	R
Acetic acid, 10-15%	C	R	C	R	R	C	R
Benzene	C	R	R	R	N	R	R
Butyl alcohol	R	C	R	R	R	N	R
Chlorine, wet, dry	C	C	C	R	R	R	R
Ethyl alcohol	R	C	R	R	R	R	R
Fatty acids	C	R	C	R	R	R	R
Formaldehyde, to 37%	R	R	R	R	R	R	R
Hydrochloric acid, to 36%	C	R	R	R	R	R	R
Kerosene	R	R	R	R	R	R	R
Methyl ethyl ketone, 100%	N	N	N	N	N	N	N
Nitric acid, to 20%	N	N	R	R	R	R	R
Nitric acid, 20-40%	N	N	R	R	N	N	C
Phosphoric acid	R	R	R	R	R	R	R
Sodium hydroxide, to 25%	R	R	R	N	R	R	R
Sodium hydroxide, 25-50%	R	C	R	N	R	C	R
Sodium hypochlorite, to 6%	C	R	R	R	R	R	R
Sulfuric acid, to 50%	R	R	R	R	R	R	R
Sulfuric acid, 50-75%	C	R	R	R	C	R	R
Xylene	N	R	R	R	R	N	R

RT, room temperature; R, recommended; N, not recommended; C, conditional.

2.1.3. Komposisi Cat

Cat terdiri dari *binder* (pengikat), pigmen, aditif, dan *solvent* (pelarut). Pada Gambar 2.2 dapat dilihat berbagai komponen-komponen penyusun cat. Untuk mendapatkan suatu cat yang memuaskan dari bila dilihat dari aspek teknik, kesehatan, keselamatan, lingkungan serta ekonomi sangatlah sulit. Perubahan kecil dalam komposisi cat dapat sangat mempengaruhi produk cat yang dihasilkan. Jika ada penambahan zat atau bahan lain yang tidak direkomendasikan oleh pembuat cat maka menyebabkan keseimbangan yang ada dalam cat akan terganggu sehingga dapat mengakibatkan perubahan sifat yang juga dapat berujung pada kegagalan aplikasi cat.



Gambar 2. 2 Bahan- bahan penyusun cat [4]

Jotun, *Jotun Paint School Modul Chapter 2 – What is Paint*, Jotun, Norwegia, 1998.

2.1.3.1. Pengikat (*Binder*)

Binder atau *resin* merupakan unsur pembentuk film pada pelapisan organik, di mana *binder* akan membentuk matriks berupa fasa polimerik yang kontinu pada lapisan organik. Berat jenis dan komposisi dari *resin* sangat menentukan permeabilitas, ketahanan kimia, dan ketahanan sinar ultraviolet dari lapisan organik. Proses terbentuknya lapisan film yang kontinu terjadi melalui proses *curing*, baik secara fisika, kimia, ataupun keduanya. Proses *curing* secara fisika didapatkan dengan proses *sintering* (pemanasan). Contoh dari *curing* secara fisika ialah zat lapis organik yang berjenis *thermoplastic* dipanaskan di dalam oven, sehingga serbuk *binder* dapat terdeposit pada permukaan logam.

Pada proses *curing* secara kimia, pembentukan lapisan film terjadi melalui reaksi kimia yang dapat berupa *reactive curing* maupun *oxidative curing*. Pada *reactive curing* terjadi reaksi *crosslinking*. Sedangkan pada *oxidative curing*, oksigen dan atmosfer bereaksi dengan monomer-monomer *binder* sehingga menyebabkan reaksi polimerisasi [2]. Jenis *binder* yang digunakan berbagai macam, seperti *epoxy*, *acrylic*, *polyurethane*, *polyester*, *alkyd*, dll. Masing-masing *binder* tersebut memiliki sifat yang berbeda satu sama lain [2]. Oleh karena itu di dalam menentukan jenis lapisan organik yang akan digunakan harus diperhatikan lingkungan operasi dan juga sifat-sifat yang dimiliki masing-masing *binder*.

2.1.3.2. Pigmen

Pigment yang ada pada lapisan organik bertujuan untuk memberikan warna pada sistem pelapisan sehingga meningkatkan sifat dekoratif. Selain itu unsur *pigment* juga dapat meningkatkan sifat proteksi korosi dari lapisan organik. Di dalam memproteksi substrat logam dari korosi, *pigment* dapat bekerja sebagai zat *inhibitor* seperti *phosphate*, zat yang dikorbankan seperti seng, serta zat penghalang seperti kaca [9].

Sebagai *inhibitor*, pigmen merupakan zat yang dapat larut di dalam air yang berpenetrasi pada lapisan organik. Sehingga saat menyentuh permukaan logam, zat tersebut mendorong terbentuknya lapisan pelindung yang akan melindungi permukaan logam dari korosi. Sebagai zat penghalang, *pigment* memiliki ketahanan terhadap zat kimia. Jenis pigmen yang terkandung di dalam

lapisan organik harus cocok dengan *resin* dan juga harus tahan terhadap lingkungan di mana lapisan organik berada [2].

2.1.3.3. Pelarut (*Solvent*)

Tujuan dari komponen *solvent* ialah untuk mengurangi viskositas (kekentalan) dari *resin* dan komponen lainnya sehingga menghasilkan pencampuran yang homogen. Dengan berkurangnya viskositas maka zat lapis organik akan mudah diaplikasikan pada substrat sehingga menghasilkan lapisan film yang tipis, halus, dan merata/kontinu. Pelarut organik dibutuhkan saat pengaplikasian zat lapis organik pada substrat. Tetapi setelah pengaplikasian tersebut, pelarut didesain untuk menguap dari lapisan film organik yang masih basah, jika ada pelarut yang tidak menguap, maka akan menyebabkan kegagalan pada lapisan organik, seperti *blistering* dan *pinhole*.

2.1.3.4. Aditif

Untuk tujuan proteksi korosi, komponen paling utama pada lapisan organik ialah *binder* dan pigmen. Komponen aditif diperlukan saat proses manufaktur, pengaplikasian, dan *cure* dari lapisan organik. Fungsi dari aditif tersebut ialah sebagai pengontrol aliran dan dispersi, reagen yang reaktif, dan zat kimia yang tahan terhadap lingkungan tertentu.

Sebagai pengontrol aliran dispersi, aditif membuat lapisan organik dapat mengontrol sifatnya saat dalam keadaan basah, baik saat pencampuran, pengaplikasian maupun proses *curing*. Jadi, zat lapis organik dapat membasahi substrat logam dengan merata sehingga membentuk film yang kontinu sepanjang permukaan logam. Sebagai reagen yang reaktif, aditif membantu dalam hal pembentukan film, membentuk ikatan pada substrat, proses *crosslinking*, dan *curing*. Sebagai zat kimia yang tahan terhadap lingkungan tertentu, zat aditif dapat memberikan perlindungan terhadap suatu lingkungan tertentu seperti sinar UV dan lingkungan laut [9].

2.1.4. Sistem Pelapisan

Sistem pelapisan substrat oleh cat umumnya terdiri atas dua hingga empat sistem pelapis baik oleh sejumlah cat sejenis maupun yang berbeda jenis. Dan umumnya dibagi atas 3 sistem lapisan yaitu:

- Lapisan Primer
- Lapisan Intermediate (*Midcoats*)
- Lapisan Luar (*Topcoats*)

Setiap lapisan ini memiliki fungsi masing-masing, namun ada juga suatu jenis cat yang memiliki dua peran sistem sekaligus. Berikut penjelasannya[7]:

2.1.4.1. Lapisan Primer

Lapisan primer merupakan komponen universal dari semua anti-korosi *coating* dan dianggap sebagai salah satu elemen paling penting dari sistem proteksi. Lapisan primer yang baik memiliki kemampuan untuk menahan atau memperlambat penyebaran cacat yang disebabkan oleh korosi seperti *pinhole*, *holidays*, atau rusaknya lapisan film. Lapisan primer harus memiliki ikatan adhesi yang kuat dengan substrat, dan menjadi basis yang baik bagi lapisan cat berikutnya. Jika sistem lapisan primer ini melindungi dengan cara mekanisme inhibisi, haruslah mengandung pigmen inhibisi yang dapat membentuk lapisan pasif untuk mengurangi kemungkinan terjadinya korosi, seperti kromat. Fungsi utama dari lapisan primer adalah:

- Memiliki daya lekat atau ikatan yang kuat dengan substrat
- Memiliki kohesi atau kekuatan internal
- Tidak bereaksi dengan lingkungan
- Memiliki ikatan atau kelekatan yang baik dengan *midcoats*
- Memiliki kelenturan yang tepat

2.1.4.2. Lapisan Intermediate (*Midcoats*)

Lapisan menengah atau *intermediate coat* diaplikasikan diantara lapisan primer dan lapisan atas cat. *Midcoats* ini biasa digunakan untuk aplikasi yang

spesifik dimana ketebalan lapisan dan struktur menjadi sebuah keuntungan. Lapisan ini haruslah memiliki kemampuan mengikat yang baik pada lapisan primer, kekuatan mekanis yang tinggi, kemampuan melindungi yang baik, dan memiliki warna yang tidak jauh berbeda dengan lapisan atas cat namun memiliki kontras yang berbeda agar tidak membingungkan pada aplikasi di lapangan. Campuran untuk lapisan tengah ini haruslah tepat dan umumnya memiliki ketebalan yang cukup besar. Sama seperti lapisan primer, lapisan menengah ini haruslah dapat menjadi basis yang baik untuk lapisan paling atas (*top coat*) dan mudah terbasahi agar tidak terbentuk *void* dan tidak terjadi kegagalan *adhesi* antara lapisan cat. Tujuan dari lapisan menengah ini adalah untuk:

- Memberi ketebalan untuk fungsi proteksi
- Tahan terhadap reaksi kimia
- Tahan terhadap transfer uap air
- Memberi ikatan yang kuat antara lapisan primer dan lapisan luar

2.1.4.3. Lapisan Luar (*Topcoats*)

Lapisan ini merupakan lapisan terakhir dari sistem pelapisan cat. Lapisan atas / topcoat didesain untuk melindungi cat dari lingkungan luar (seperti angin, hujan, temperatur, mikrobiologi, senyawa kimia yang agresif serta polutan pada atmosfer) dan memiliki kontribusi perlindungan keseluruhan terhadap korosi serta memiliki warna dan tingkat kilap yang diharapkan pada aplikasi. Lapisan akhir ini diharapkan tidak mengalami pengkapuran (*chalking*) yang disebabkan oleh sinar ultraviolet atau sinar matahari serta memiliki daya adhesi yang baik meskipun pada daerah yang lembab atau basah. Pastinya, sebagai lapisan terluar, topcoat ini harus memiliki sifat mekanis yang baik agar tahan terhadap goresan, dampak fisik dan abrasi. Fungsi utama dari lapisan luar (*topcoats*) adalah untuk:

- Penghalang utama dari lingkungan
- Memberi ketahanan akan kimia, air, serta cuaca
- Memberi ketangguhan dan ketahanan terhadap aus pada permukaan
- Memberi penampilan yang menarik

Intinya, sistem pelapisan yang dimiliki suatu produk harus memenuhi beberapa persyaratan seperti :

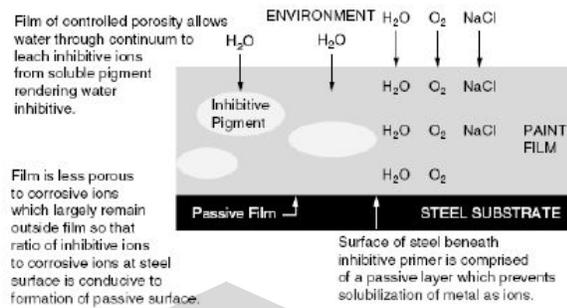
- Umur pakai (*design life*)
- Mudah dilakukan perbaikan pada sistem di masa yang akan datang
- Memenuhi kelas atau klasifikasi tertentu
- Memenuhi standar internasional tertentu
- Kesehatan dan keselamatan pekerja terjaga, serta aman bagi lingkungan

Bagaimanapun juga ada beberapa situasi dimana lapisan menengah (*intermediate coats*) memberikan perlindungan untuk lapisan primer dari lingkungan, dan lapisan luar (*topcoats*) digunakan untuk tujuan yang berbeda. Lapisan luar (*topcoats*) dapat digunakan, sebagai contoh, untuk memberikan permukaan yang tidak licin, dan lapisan menengah (*intermediate coats*) dan primer digunakan untuk penghalang dari lingkungan, seperti yang digunakan pada lingkungan air laut.

2.1.5. Mekanisme Perlindungan Korosi oleh *Coating*

2.1.5.1. Efek Inhibisi (*Inhibitor Effect*)

Prinsip *inhibitor effect* yaitu melindungi dengan cara menambahkan suatu zat inhibitor pada komposisi cat primer sebagai bagian dari pigmen untuk menahan laju korosi. Zat inhibitor ini umumnya hanya ditambahkan pada lapisan primer saja, dan mengandung pigmen yang bereaksi ketika uap air masuk terserap pada lapisan cat. Adanya uap air yang bereaksi dengan zat inhibitor ini akan menghasilkan suatu lapisan pasif tipis yang mempasifasi area atau jalur uap air menuju substrat. Pigmen yang bersifat inhibisi ini bersifat aktif, yang mana pigmen tersebut akan mengalami ionisasi ketika ada uap air yang terserap pada lapisan cat. Proteksi jenis ini umumnya hanya berfungsi untuk perlindungan atmosferik, karena pada lingkungan yang basah atau terendam akan mudah terjadi *osmotic blistering* akibat dari pigmen yang sensitif terhadap air.

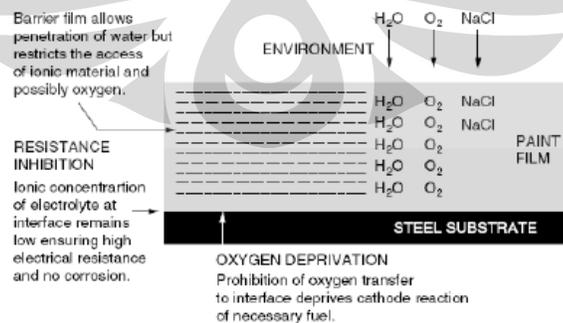


Gambar 2. 3 Mekanisme perlindungan inhibisi oleh pigmen [8]

Tracton, Arthur A., *Coating Technology Handbook, 3rd edition*, Taylor & Francais Group, New York, 2006

2.1.5.2. Efek Penghalang (*Barrier Effect*)

Prinsip *barrier effect* yaitu melindungi dengan cara melapisi cat yang kedap air dengan ketebalan tertentu pada logam, dan biasa digunakan pada area-area terendam, contohnya adalah bitumen, epoksi, dan lain-lain. Efek penghalang merupakan konsep dasar dari hampir seluruh lapisan antikorosi. Namun tidak ada lapisan yang tidak memiliki permeabilitas. Lapisan penghalang didesain agar substrat tidak bereaksi langsung dan terpengaruh oleh uap air, atau udara yang mengandung atom-atom oksigen. Serta lapisan pelindung umumnya harus tahan terhadap senyawa kimia disekitarnya. Gaya adhesi pada bagian bawa lapisan yang kontak langsung dengan substrat haruslah baik dan harus sepenuhnya membasahi permukaan agar mencegah terjadinya cacat (*void*) pada permukaan substrat.



Gambar 2. 4 Mekanisme perlindungan lapisan penghalang [8]

Tracton, Arthur A., *Coating Technology Handbook, 3rd edition*, Taylor & Francais Group, New York, 2006

2.1.5.3. Proteksi Katodik

Mekanisme ini berdasarkan prinsip *galvanic effect* yaitu melindungi dengan cara proteksi seperti pada sistem proteksi katodik atau galvanis. Efek galvanis ini dapat dicapai karena cat tersebut mengandung seng (bertindak sebagai anoda korban). Konsepnya adalah ketika uap air terserap oleh lapisan cat, maka akan terjadi reaksi pada pigmen yang umumnya adalah seng, sehingga pigmen seng menjadi anoda dan lebih dulu terkorosi. Kelebihan metode ini adalah walaupun terjadi goresan pada lapisannya, sistem proteksi katodik tetap berjalan seperti diilustrasikan pada gambar 2.1.

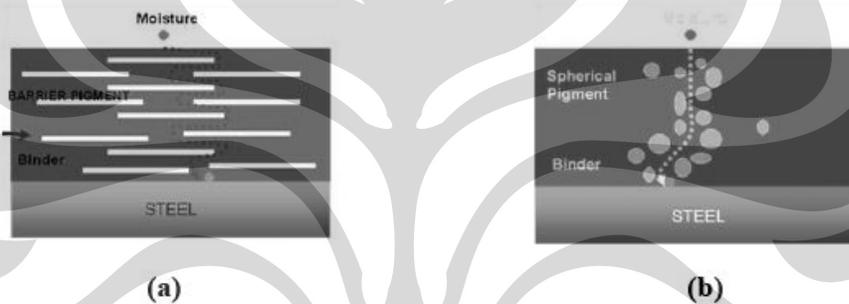
2.1.6. Kerusakan Cat

Kerusakan dalam aplikasi cat untuk perlindungan korosi ada dua mekanisme degradasi lapisan yang terlihat dan penting secara teknis yaitu delaminasi katodik dan pengangkatan oksida tetapi sebelumnya diawali dengan tembusnya lapisan cat oleh *moisture* udara sehingga dan terjadi korosi pada batas logam dan pelapis. Korosi dibawah cat dapat terjadi hanya setelah terbentuk lapisan ganda elektrokimia pada permukaan logam. Ini terjadi jika adesi antara lapisan cat dan logam telah rusak, setelah adesi hilang maka akan terbentuk lapisan tipis molekul air yang memisahkan antara cat dengan logam ketika air meresap pada lapisan cat.

Beberapa besarnya kandungan air yang terserap oleh lapisan cat tergantung pada beberapa hal seperti berikut ini [11]:

- Gradien konsentrasi, misalnya selama pencelupan atau ekspos pada atmosfer yang lembab, menghasilkan difusi menembus polymer cat
- Osmosis mengacu pada endapan-endapan, hasil korosi pada batas cat dan logam
- Gaya kapilaritas / permeabilitas terhadap air dan uap air pada cat karena mengacu pada pengeringan cat atau proses curing yang buruk, pelarut yang tidak cocok, interaksi yang buruk antara pengikat dan aditif atau adanya udara yang terperangkap selama pengecatan dalam cat ataupun lubang lubang pada cat.

- Ketebalan lapisan, ketebalan lapisan berpengaruh terhadap waktu moisture untuk menembus ke dalam lapisan substrat (permeation time). Semakin tebal maka semakin lama waktu yang dibutuhkan moisture untuk tembus ke lapisan substrat. Namun Funke [11] melaporkan bahwa *coating* dengan ketebalan lapisan primer tidaklah harus tebal sepanjang lapisan atas (*topcoat*) memiliki sifat penghalang yang masih baik. Jadi kombinasi ketebalan antara primer, *intermediate* dan *topcoat* haruslah tepat. Dan tidak perlu terlalu tebal.
- Bentuk pigmen, pigmen yang berbentuk serpihan atau *flake* akan lebih melindungi dibandingkan pigmen yang berbentuk lingkaran atau pipih.



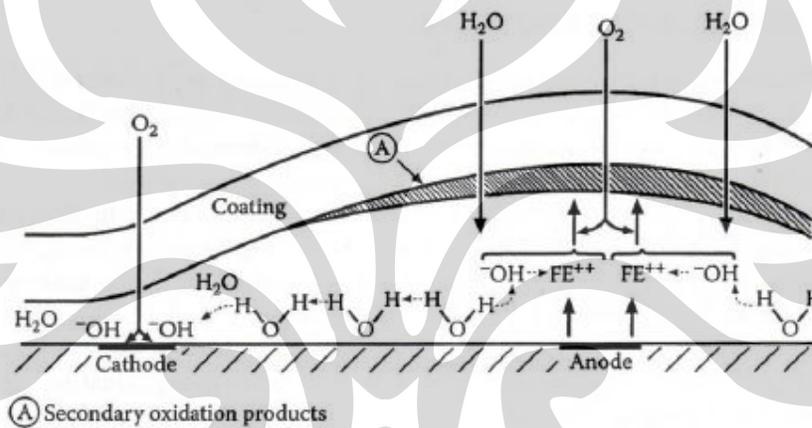
Gambar 2. 5 Pengaruh perbedaan bentuk pigmen terhadap jalur uap air melewati lapisan (a) pigmen berbentuk *flake* yang lebih menghalangi jalur uap air (b) pigmen berbentuk bundar atau pipih yang mudah ditembus oleh uap air [12]

Azkonobel – International Paint, *Technical Module 1-10*, (Ms. Office Power Point slide show)

Ketika sistem pelapis diekspos pada atmosfer yang lembab atau dengan kelembaban 100%, molekul air mencapai batas antara pelapis-substrat. Umumnya pelapis akan jenuh setelah beberapa waktu, tergantung pada harga koefisien difusi dan kelarutan serta ketebalan lapisan. Untuk ekspos atmosferik perubahan siklik aktual temperatur dan kelembaban sangat menentukan periode kejenuhan. Pada suatu kasus, molekul air akan mencapai batas antara pelapis-logam, dimana dapat mengganggu ikatan antara dua fasa, dapat terjadi karena kehilangan adesi dan inisiasi korosi jika reaksi katodik terjadi[9]. Agar reaksi korosi berlanjut, memerlukan suplai air atau oksigen yang konstan. Peresapan air juga dapat menghasilkan tekanan osmosis yang tinggi yang berperan pada pembentukan

blistering dan delaminasi. Ketika molekul air telah sampai pada batas antara logam dan cat, maka akan mengganggu adhesi antara lapisan cat dan logam. Derajat dimana air meresap dapat merubah sifat adhesi sistem pelapis dikenal sebagai adesi basah (*wet adhesion*). Mekanisme kehilangan adhesi karena air ada dua hipotesa yang berbeda diusulkan oleh Leidheiser dan Funke [13]:

1. Pelepasan (*disbondment*) kimia karena interaksi molekul air dengan ikatan kovalen, hidrogen atau polar antara polimer dan logam (oksida logam)
2. Pelepasan mekanik atau hidrodinamis karena gaya yang disebabkan oleh akumulasi air dan tekanan osmosis



Gambar 2.6 Mekanisme blistering yang dikemukakan oleh Funke [9]

Forgesen, Amy, *Corrosion Control Through Organic Coatings*, Taylor & Francais Group, New York, 2006.

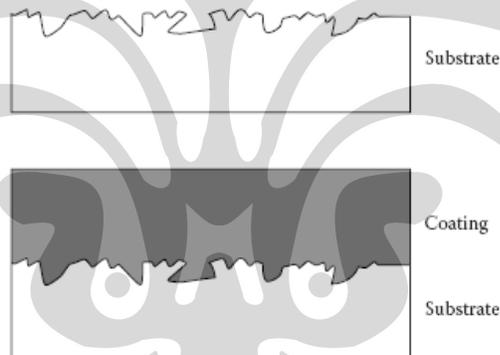
Pembentukan blister pada korosi bawah lapisan dihasilkan dari beragam fenomena termasuk *swelling* (pengerutan) pelapis selama peresapan air, adanya rongga, inklusi gas, ion-ion pengotor pada lapisan, masalah adesi basah, adesi general yang kurang kuat, dan cacat pada lapisan. Secara umum pembentukan blister ditunjukkan oleh gambar 2.5. Kehilangan adhesi dikenal sebagai delaminasi katodik dengan gaya dorongnya adalah reaksi katodik dimana terjadi pemisahan tempat reaksi anodik dan katodik[13]. Perambatan blister karena delaminasi katodik dibawah pelapis organik yang tidak rusak pada substrat. Dibawah peresapan lapisan, korosi dapat diawali terlokalisir pada tempat yang adesinya kurang. Setelah inisiasi korosi lokal, besi oksida hidroksida akan terbentuk oleh reaksi Fe^{2+} dan OH^- dengan oksigen.

2.2. Teori Daya Lekat (*Adhesi*)

Adhesi merupakan suatu fenomena yang terjadi pada *interface* (lapisan antarmuka) yang berhubungan dengan efek fisik dari reaksi kimia. Dalam hal ini, adesi merupakan interaksi antara coating dengan substrat logam. Ada tiga teori berkaitan dengan adesi, yaitu *mechanical bonding* (ikatan mekanik), *electrostatic attraction*, dan *chemical bonding* (ikatan kimia) [2]. Penjelasan dari teori tersebut ialah sebagai berikut:

1. *Mechanical Bonding*

Saat permukaan substrat yang mengandung pori, lubang, atau celah diaplikasikan *coating*, maka *coating* akan berpenetrasi ke dalam celah tersebut. Sehingga saat *coating* mengering, maka akan terbentuk *mechanical bonding* antara *coating* dengan substrat, seperti ditunjukkan oleh gambar 2.6. Permukaan substrat yang kasar dapat meningkatkan adesi dari *coating* pada substrat.



Gambar 2. 7 Skema *mechanical bonding* antara *coating* dengan substrat [2]
Schweitzer, Philip, *Paint and Coatings*, Taylor and Francis Group, Amerika Serikat, 2006.

2. *Electrostatic Attraction*

Gaya elektrostatis dapat terjadi pada *interface* antara *coating* dengan substrat. Adanya perbedaan *electrical charge* antara *coating* dengan substrat membentuk adesi *coating* pada substrat.

3. *Chemical Bonding*

Ikatan kimia yang terjadi pada *interface* seringkali terdapat pada *thermoset coating*. Ikatan tersebut merupakan ikatan yang sangat kuat dan tahan lama. Untuk terjadinya ikatan kimia maka diperlukan suatu *reactive chemical group*, seperti silane, yang dapat menciptakan ikatan yang kuat antara *coating* dengan substrat.

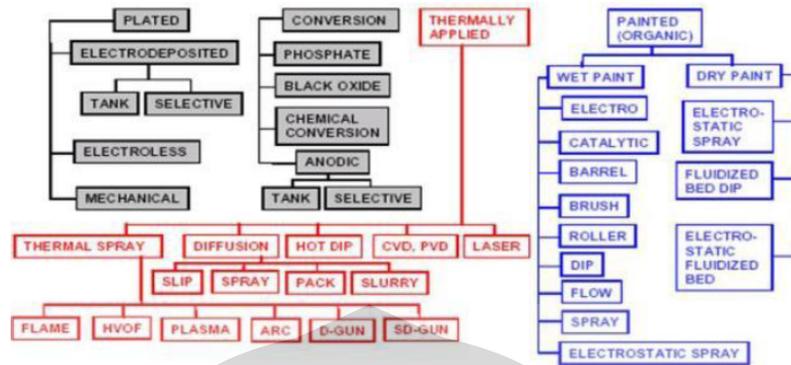
2.3. Persiapan Permukaan

Suatu lapisan organik harus memiliki kemampuan untuk melekat pada permukaan substrat. Oleh karena itu substrat yang akan dilapisi harus bebas dari kotoran seperti minyak dan produk korosi. Dan untuk mendapatkannya maka diperlukan suatu proses yang disebut dengan preparasi permukaan. Preparasi permukaan merupakan proses yang meliputi pengkasaran permukaan untuk mendapatkan *mechanical bonding* dan juga untuk menghilangkan karat, minyak, lemak, dan pengotor lainnya. Dengan permukaan substrat yang bersih dan kasar maka zat lapis organik diharapkan dapat melekat dengan baik. Proses ini dapat dilakukan secara mekanik seperti *grit-blast* dan *sandblast*, ataupun secara kimia seperti *pickling* dan *degreasing*. Pemilihan metode preparasi permukaan itu sendiri dipengaruhi oleh beberapa faktor seperti logam yang akan dilapisi, bentuk dan ukuran komponen, sistem pelapisan, serta kondisi operasi [10].

Hal penting di dalam pengaplikasian lapisan organik ialah preparasi permukaan untuk mendapatkan daya lekat (adesi) yang baik serta ketebalan yang diinginkan. Karena preparasi permukaan memegang peranan penting, maka terdapat suatu standar yang mengatur metode preparasi permukaan. Metode standar yang biasa digunakan ialah standar yang dikeluarkan oleh *Steel Structures Painting Council (SSPC)* dan *International Standard Organization (ISO)*.

2.4. Metode Pengaplikasian

Terdapat beberapa metode pengaplikasian zat lapis organik pada substrat logam, yaitu seperti *brushing*, *roller*, *spray coating*, *powder coating*, serta *electrodepositing*. Selain metode tersebut terdapat pula berbagai metode yang dapat digunakan, seperti yang ditunjukkan pada gambar 2.4. Pemilihan metode yang akan digunakan dalam pengaplikasian zat lapis tersebut dipengaruhi oleh beberapa hal, yaitu tujuan pelapisan, lingkungan di mana zat lapis organik akan ditempatkan, jenis zat lapis organik, bentuk dan ukuran dari komponen yang akan dilapisi, waktu pengaplikasian, serta biaya. Pemilihan metode tersebut didasarkan pada sifat cat seperti viskositas, kemudahan dan karakteristik lapisan kering yang ingin dihasilkan.



Gambar 2. 8 Metode – metode pengaplikasian *coating*

Untuk penggunaan kuas (*brushing*) umumnya ditujukan untuk *spot coating*, daerah lasan, daerah sempit ataupun area yang berukuran kecil. Sedangkan untuk cat yang memiliki *potlife* (waktu maksimal pada wadah pengaplikasian) yang singkat, lebih sering digunakan *roller* dalam pengaplikasiannya. Setelah diaplikasikan dengan metode tertentu, maka akan dihasilkan lapisan cat yang kering, padat dengan tebal lapisan optimal. Tebal lapisan ini sangat penting dalam memberi perlindungan terhadap korosi, bila terlalu tipis maka ion, gas dan air akan mudah masuk dan bila terlalu tebal dapat mudah retak dan mengelupas.

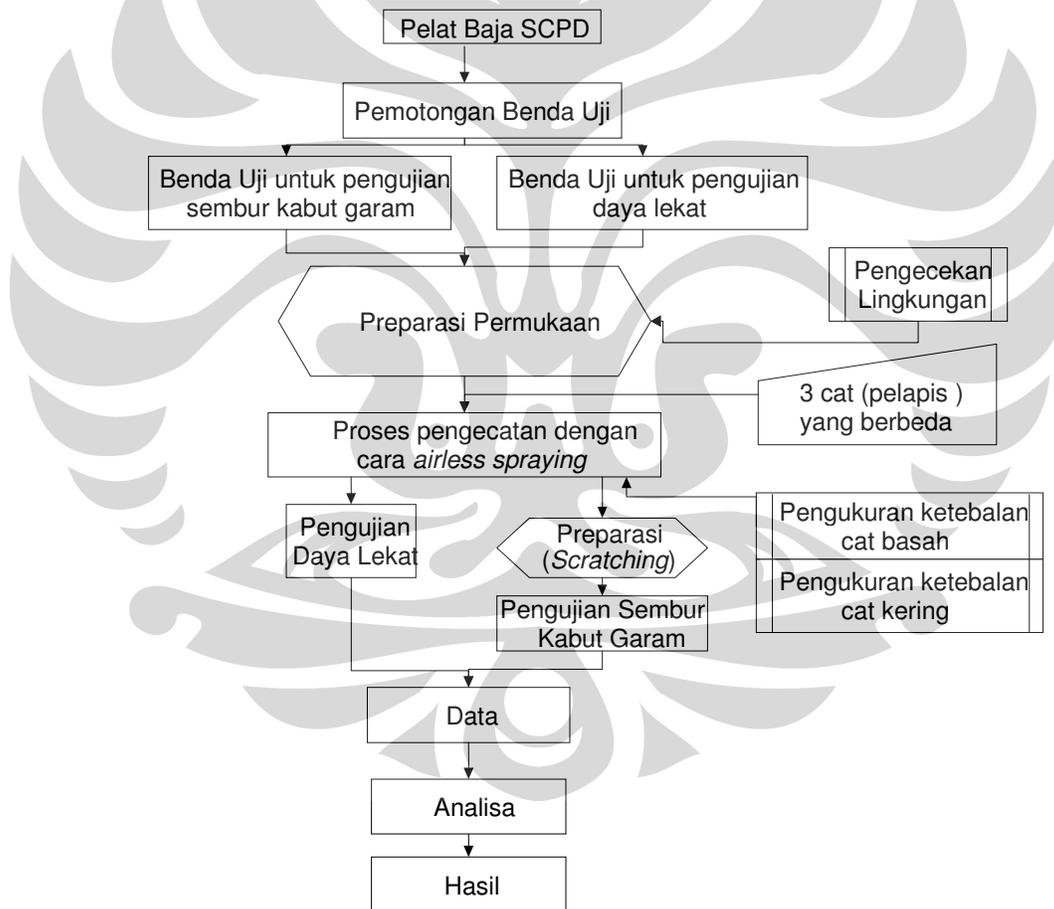
Untuk menghasilkan lapisan yang baik dan tingkat keseragamannya tinggi (merata), penggunaan *spray gun* paling banyak digunakan. *Spray gun* terbagi menjadi dua yaitu *air spray* dan *airless spray*. *Air spray* mendeposisikan cat dengan bantuan *compressor* udara sehingga dipengaruhi oleh kecepatan angin di lingkungan sekitar bila melakukan aplikasi di luar ruangan. Sedangkan *Airless spray* menembakkan cat melalui saluran bertekanan tinggi (sekitar 1000-1600 Psi). Tidak adanya udara pengatomisasi pada *airless spray* mencegah terjadinya kontaminasi dari minyak atau udara yang terkompresi di dalam kompresor. dalam pengaplikasian cat ini perlu diperhatikan *pot life* cat. Apabila cat memiliki *pot life* yang singkat, penggunaan *spray gun* menjadi sulit karena cat dapat tertinggal dan mengering pada lubang *orifice gun*, sehingga pengontrolan waktu pengaplikasian menjadi penting.

BAB 3

METODOLOGI PENELITIAN

3.1. Diagram Alir Penelitian

Pada penelitian ini akan dilakukan pelapisan menggunakan *organic coating* dengan metode *airless spraying*, dimana sebelumnya substrat baja karbon rendah dilakukan preparasi permukaan berdasarkan ISO agar didapat daya lekat yang lebih baik. Variabel yang digunakan yaitu perbedaan pengikat dan pigmen pada *organic coating* yaitu epoksi, *zinc silicate*, dan *zinc phosphate*.



Gambar 3. 1 Diagram Alir Penelitian

3.2. Alat & Bahan

3.2.1. Alat

Peralatan yang digunakan dalam penelitian ini adalah:

1. Alat pemotong pelat
2. *Spray* dan kompresor
3. Sikat besi dan *sand blasting machine*
4. *Sand blasted* sample SA 1
5. *Humiditymeter*
6. Wadah dan pengaduk
7. *Cutter*
8. *Digital Caliper* dengan ketelitian 0,01 mm
9. *Wet film thickness gauge comb*
10. *Elcometer coating thickness gauges*
11. *Pull-off strength tester*
12. *Measuring microscope*
13. *Salt spray cabinet*

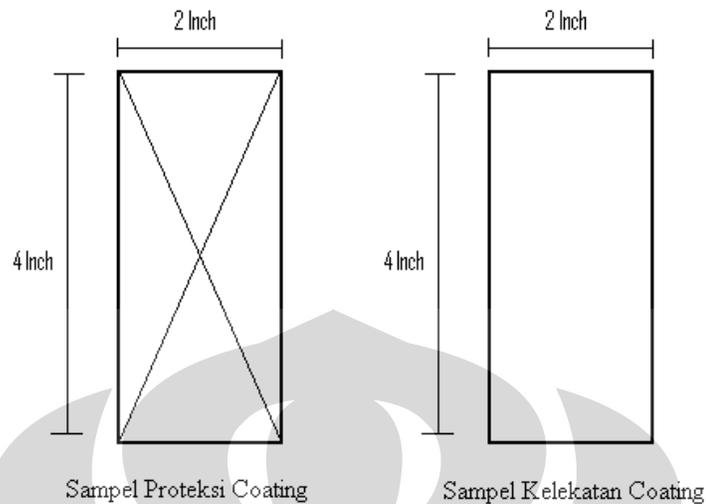
3.2.2. Bahan

Bahan-bahan yang dibutuhkan dalam penelitian ini antara lain:

1. Material *coating* epoksi
2. Material *coating zinc silicate*
3. Material *coating zinc-rich* epoksi
4. Lem epoksi (Araldite)
5. Larutan NaCl 5%

3.3. Benda Uji

Benda uji atau sample adalah pelat baja karbon rendah (SCPD) dengan ukuran 2 inci x 4 inci. Pelat tersebut kemudian dibersihkan dan dipersiapkan sedemikian rupa kemudian dilapisi cat *zinc-rich*, *zinc silicate* dan epoksi. Untuk pengujian sembur kabut garam akan diberi goresan menyilang sebesar ± 1 mm seperti yang diilustrasikan pada Gambar 3.1.

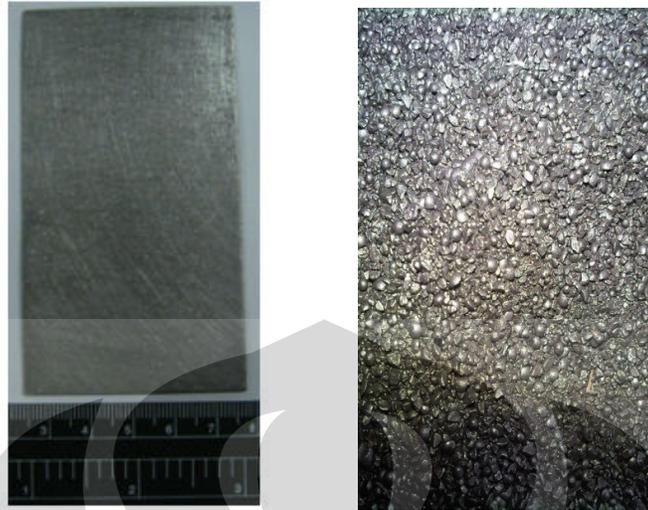


Gambar 3. 2 Ilustrasi Bentuk Sampel

3.4. Prosedur Penelitian

3.4.1. Persiapan Permukaan

Pembersihan permukaan yang dilakukan adalah dengan metode *sand blasting* (ISO8501-1), yang sebelumnya dilakukan proses pra pembersihan dengan metode *hand and power tool cleaning* (ISO8501-1). *Hand tool cleaning* dilakukan dengan menggunakan kertas amplas, sikat besi, dan scrapper. Pembersihan dengan metode ini dilakukan untuk membersihkan benda uji dari debu, sisa-sisa gerinda atau pengotor lainnya. Sedangkan *power tool cleaning* dilakukan dengan menggunakan mesin penyikat dan mesin gerinda dengan tujuan menghilangkan karat, *slag*, ataupun bagian sisa hasil dari pemotongan. Setelah itu, benda uji siap dibersihkan dengan tujuan bebas dari *mill scale*, oli, minyak, karat dan pengotor lainnya menggunakan metode *sand blasting* (ISO8501-1). Hasil dari *sand blasting* dapat dilihat dari Gambar 3.2. *Sand blasting* dilakukan oleh teknisi di PT. Harsa Wirasakti dengan umpan campuran baja berbentuk bulat (*steel shot*) dan bentuk tajam (*steel grit*).



Gambar 3. 3 Penampakan benda uji dan media blasting(a) benda uji setelah diblasting dengan SA 1, (b) umpan baja yang digunakan

3.4.2. Pengecekan Kondisi Lingkungan

Pada saat proses pelapisan, kondisi lingkungan dicek terlebih dahulu. Kondisi lingkungan yang dimaksud disini adalah temperatur udara dan kelembapan udara. Pelat baja yang akan di cat harus dipastikan telah memenuhi standar kebersihan dan kekasaran dengan Sa 1 dengan menggunakan alat KTA komparator dan kaca pembesar.

Sebelum dilakukan *sand blasting* dan pengecatan dilakukan proses pengujian lingkungan (*environmental test*) berdasarkan ASTM E337, pengujian ini ditujukan guna mengetahui tingkat kelembapan udara (*relative humidity*), temperatur *dew point*, temperatur permukaan material, dan kecepatan angin. Proses pelapisan ini sangat tergantung pada faktor-faktor tersebut. RH (*relative humidity*) yang diperbolehkan maksimal adalah 85% dan *dew point* haruslah 3°C diatas temperatur permukaan baja atau substrat.



Gambar 3. 4 Alat pengukur temperatur dan RH

3.4.3. Proses Pengecatan

Proses pelapisan / pengaplikasian cat dilakukan dengan menggunakan *airless spray* hingga dicapai *wet film thickness (wft)* yang diinginkan. Pengujian ketebalan basah menggunakan *WFT gauge*. Pengecatan ini dilakukan oleh teknisi di PT. Harsa Wirasakti menggunakan alat *airless spray*.



Gambar 3. 5 Alat ukur *wft*

Selanjutnya setelah mencapai *curing time* nya yaitu 7 hari setelah pengaplikasian cat, maka dilakukan pengukuran *dft (dry film thickness)*, dengan menggunakan alat *elcometer coating thickness gauge*, dimana pengukuran dilakukan pada tiga titik atau daerah berbeda yaitu pada permukaan bagian atas, tengah dan bawah dari sampel dan kemudian nilainya dirata-rata untuk mendapatkan ketebalan lapisan dari lapisan cat tersebut.



Gambar 3. 6 *Elcometer Coating Thickness Gauge*

3.4.4. Pengujian Daya Lekat

Pengujian daya lekat menggunakan alat *Portable Adhesion Testers* sesuai dengan standar ASTM D4541. Pengujian ini dilakukan ketika cat pada sample telah memasuki tahap *hard dry* sesuai pada PDS masing-masing cat. Kemudian *probe* dari *Portable Adhesion Testers* diberi lem kuat dan ditempelkan pada sample dan ditunggu hingga mengering sampai 1 hari, baru kemudian ditarik oleh *Portable Adhesion Testers*. Pengujian ini dilakukan guna mengetahui seberapa besar daya lekat (adhesi) cat terhadap material substratnya. Pengujian ini dilakukan di PT. Sigma Utama.

Hal ini dilakukan dengan kondisi :

- Menempelkan probe dolly ke material yang telah di cat dengan lem yang cukup kuat sehingga daya lekat antara probe dengan cat > daya lekat antara cat dengan material, lalu menunggu sekitar dua hari sampai lem tersebut benar-benar kering dan memiliki kekuatan yang cukup.
- Menyangkutkan probe dolly ke alat penguji dolly testing, mengeset pengukuran ke titik nol dan memutar alat dolly testing secara perlahan tetapi terus menerus hingga probe mencabut lapisan cat yang ada pada material.
- Membaca dan mencatat nilai yang terlihat dalam indikator alat, baik dalam lb/inch^2 maupun dalam Mpa.



Gambar 3.7 Elcometer model 106 adhesion tester scale 1

3.4.5. Pengujian Sembur Kabut Garam

Pengujian sembur kabut garam dilakukan dengan sebelumnya menggores lapisan cat ini dilakukan untuk mengetahui tingkat ketahanan korosi dari ketiga jenis material cat yang berbeda. Metode pengujian dengan sembur kabut garam (*salt spray test*) dilakukan secara berkesinambungan selama 120 jam, sesuai dengan standar ASTM B117, yang dilakukan di Laboratorium Korosi Departemen Metalurgi dan Material, dengan kondisi:

- Dalam ruang sembur kabut garam, benda uji berukuran 2 x 4 inci diletakkan pada tempat yang berbentuk sudut terhadap bidang horizontal dan sejajar dengan arah aliran kabut garam. Setiap benda uji diletakkan sedemikian rupa sehingga kabut garam menyentuh langsung seluruh permukaan benda uji yang telah digores.
- Di dalam ruang tersebut disemurkan larutan NaCl 5% dalam aquades dengan tekanan udara yang diatur tetap (-0.7 Kg/cm^2) sehingga laju pengkabutan konstan dan suhu dalam ruang juga diatur tetap ($\pm 38^\circ\text{C}$). Pengaruh kabut garam akan menimbulkan kerusakan berupa karat pada benda uji. Kerusakan pada benda uji diperiksa dan diamati setelah 120 jam.



Gambar 3. 8 Salt spray chamber dengan benda uji

Metode pengujian sembur kabut garam yang digunakan adalah metode goresan, dimana benda uji yang dilapisi cat digores dengan *tool steel* setebal kurang lebih 1 mm hingga terlihat substrat baja. Sehingga proses korosi akan dipercepat dengan adanya goresan ini. Lebar goresan awal adalah sekitar 1 mm. Laju korosi dilihat berdasarkan pertambahan lebar goresan, semakin lebar maka semakin cepat proses korosi terjadi, dan semakin lebar goresan yang dihasilkan maka rating dari lapisan cat semakin buruk.

Penilaian derajat kerusakan cat berdasarkan standar ASTM D1654 Prosedur A (evaluasi cat pada lingkungan korosi), yang dievaluasi berdasarkan nilai pada Tabel 3.1. Tingkat evaluasi cat pada lingkungan korosi yang diukur adalah nilai perbedaan lebar goresan pada cat sebelum dilakukan pengujian dan setelah dilakukan pengujian selama 120 jam. Pengukuran penambahan lebar goresan dilakukan dengan menggunakan *measuring microscope*.

Tabel 3. 1 Daftar peringkat dan pertambahan lebar goresan

Representative Mean Creepage From Scribe		
Millimetres	Inches (Approximate)	Rating Number
Zero	0	10
Over 0 to 0.5	0 to $\frac{1}{64}$	9
Over 0.5 to 1.0	$\frac{1}{64}$ to $\frac{1}{32}$	8
Over 1.0 to 2.0	$\frac{1}{32}$ to $\frac{1}{16}$	7
Over 2.0 to 3.0	$\frac{1}{16}$ to $\frac{1}{8}$	6
Over 3.0 to 5.0	$\frac{1}{8}$ to $\frac{3}{16}$	5
Over 5.0 to 7.0	$\frac{3}{16}$ to $\frac{1}{4}$	4
Over 7.0 to 10.0	$\frac{1}{4}$ to $\frac{3}{8}$	3
Over 10.0 to 13.0	$\frac{3}{8}$ to $\frac{1}{2}$	2
Over 13.0 to 16.0	$\frac{1}{2}$ to $\frac{5}{8}$	1
Over 16.0 to more	$\frac{5}{8}$ to more	0

BAB 4

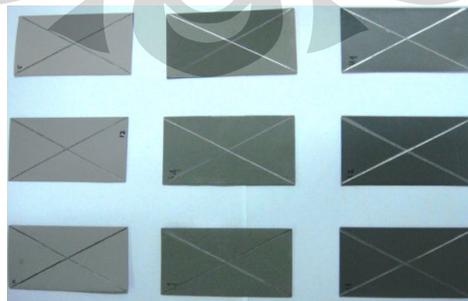
HASIL DAN PEMBAHASAN

4.1. Uji Sembur Kabut Garam

Uji sembur kabut garam (*salt spray test*) dilakukan berdasarkan standar uji ASTM B 117-03. Tujuan dari pengujian ini ialah untuk melihat ketahanan sampel uji yang permukaannya telah terlapis lapisan *organic* terhadap lingkungan korosif (yang terkontrol) yang mengandung ion-ion Cl^- , dan diketahui tingkat korositifitasnya berdasarkan standar evaluasi *coating* ASTM D1654 Prosedur A. Pengujian sembur garam dilakukan di dalam *salt spray cabinet*, di mana larutan garam NaCl 5% akan disemburkan di dalam *cabinet* tersebut.

4.1.1. Hasil Uji Sembur Kabut Garam

Berdasarkan hasil pengujian uji sembur kabut garam (*salt spray*) selama 120 jam terhadap ketiga jenis *organic coating* dengan binder dan pigmen yang berbeda (epoksi, *zinc silicate*, dan *zinc-rich* epoksi) dihasilkan nilai pertambahan lebar goresan yang tidak jauh berbeda. Pertambahan lebar goresan ini dihitung di lima titik (pojok kiri dan kanan atas, tengah, pojok kiri dan kanan bawah) lalu mengukurnya pada *measuring microscope* sebelum dilakukan pengujian, kemudian setelah dilakukan pengujian selama 120 jam pada titik yang sama diukur kembali lebar goresan apakah mengalami pertambahan lebar akibat adanya lapisan yang rusak akibat terjadi korosi yang melebar atau tidak. Dapat dilihat perbedaannya pada Gambar 4.1 dan Gambar 4.2



Gambar 4.1 Foto sampel sebelum uji sembur kabut garam (kiri: *epoxy*, tengah: *zinc silicate*, kanan: *zinc rich epoxy*)



Gambar 4. 2 Foto sampel sesudah uji sembur kabut garam (atas: epoxy, tengah: zinc silicate, bawah: zinc rich epoxy)

Pada sampel uji dengan menggunakan *zinc-rich* epoksi coating didapatkan pertambahan lebar goresan sekitar 14 μm sampai 61 μm pada sampel uji 1, dan bila disesuaikan dengan standar pengujian sembur kabut garam akan mendapatkan rating 9 atau pertambahan lebar yang kurang dari 1 mm. Untuk sampel uji 2 dan sampel uji 3 juga mendapatkan nilai rating yang sama dengan nilai pertambahan

lebar antara 34 μm hingga 131 μm pada sampel uji 2 dan nilai pertambahan lebar antara 31 μm hingga 77 μm pada sampel uji 3.

Tabel 4. 1 Lebar goresan dengan sampel *zinc-rich* epoksi *coating* sebelum dilakukan pengujian dan setelah dilakukan pengujian sembur kabut garam (dalam mm)

Titik	Sampel 1		Sampel 2		Sampel 3	
	Lebar awal	Lebar akhir	Lebar awal	Lebar akhir	Lebar awal	Lebar akhir
A	1.305	1.221	0.823	0.871	1.137	1.184
B	1.221	1.235	0.971	1.005	0.933	1.01
C	1.094	1.129	1.192	1.25	0.872	0.903
D	1	1.059	0.816	0.947	1.002	1.042
E	0.856	0.917	0.808	0.871	0.878	0.909

Tabel 4. 2 Nilai rating dan pertambahan lebar rata-rata sampel dengan *zinc-rich* epoksi *coating*

Titik	Pertambahan Lebar (mm)		
	Sampel 1	Sampel 2	Sampel 3
A	0.032	0.048	0.047
B	0.014	0.034	0.077
C	0.035	0.058	0.031
D	0.059	0.131	0.04
E	0.061	0.063	0.031
Rata-rata	0.0402	0.0668	0.0452
Rating	9	9	9

Pada sampel uji dengan menggunakan *zinc silicate coating* didapatkan pertambahan lebar goresan sekitar 72 μm sampai 97 μm pada sampel uji 1, dan bila disesuaikan dengan standar pengujian sembur kabut garam akan mendapatkan rating 9 atau pertambahan lebar yang kurang dari 1 mm. Untuk sampel uji 2 dan sampel uji 3 juga mendapatkan nilai rating yang sama dengan nilai pertambahan lebar antara 74 μm hingga 133 μm pada sampel uji 2 dan nilai pertambahan lebar antara 65 μm hingga 115 μm pada sampel uji 3.

Tabel 4. 3 Lebar goresan dengan sampel *zinc silicate coating* sebelum dilakukan pengujian dan setelah dilakukan pengujian sembur kabut garam (dalam mm)

Titik	Sampel 1		Sampel 2		Sampel 3	
	Lebar awal	Lebar akhir	Lebar awal	Lebar akhir	Lebar awal	Lebar akhir
A	1.249	1.346	1.024	1.103	0.817	0.91
B	0.987	1.059	0.868	0.954	0.997	1.062
C	1.623	1.691	0.827	0.91	0.948	1.029
D	0.825	0.917	0.935	1.009	1.05	1.136
E	1.182	1.255	0.838	0.971	0.898	1.013

Tabel 4. 4 Nilai rating dan pertambahan lebar rata-rata sampel dengan *zinc silicate coating*

Titik	Pertambahan Lebar (mm)		
	Sampel 1	Sampel 2	Sampel 3
A	0.097	0.079	0.093
B	0.072	0.086	0.065
C	0.068	0.083	0.081
D	0.092	0.074	0.086
E	0.073	0.133	0.115
Rata-rata	0.0804	0.091	0.088
Rating	9	9	9

Sedangkan pada sampel uji dengan menggunakan cat epoksi didapatkan pertambahan lebar goresan sekitar 68 μm sampai 141 μm pada sampel uji 1, dan bila disesuaikan dengan standar pengujian sembur kabut garam akan mendapatkan rating 9 atau pertambahan lebar yang kurang dari 1 mm. Untuk sampel uji 2 dan sampel uji 3 juga mendapatkan nilai rating yang sama dengan nilai pertambahan lebar antara 81 μm hingga 177 μm pada sampel uji 2 dan nilai pertambahan lebar antara 14 μm hingga 296 μm pada sampel uji 3.

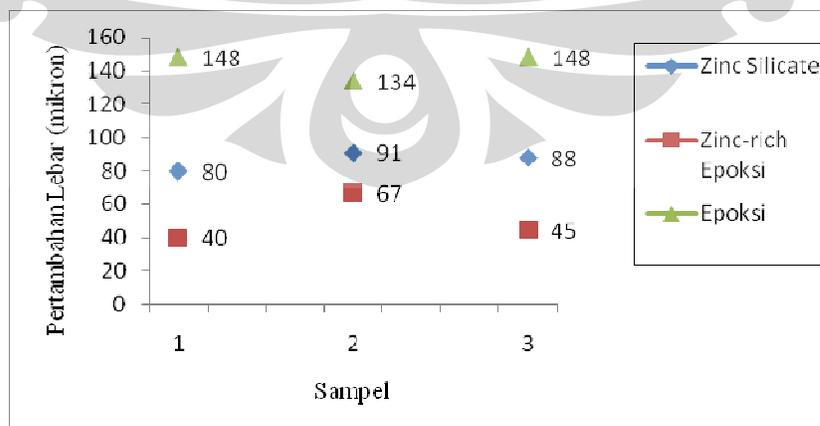
Tabel 4. 5 Lebar goresan pada sampel epoksi primer sebelum dilakukam pengujian dan setelah dilakukan pengujian sembur kabut garam

Titik	Sampel 1		Sampel 2		Sampel 3	
	Lebar awal	Lebar akhir	Lebar awal	Lebar akhir	Lebar awal	Lebar akhir
A	0.903	1.044	1.216	1.297	1.243	1.288
B	0.895	1.006	0.978	1.077	1.239	1.288
C	0.821	0.91	1.11	1.2	0.992	1.135
D	0.901	0.969	0.859	0.973	0.823	1.119
E	1.172	1.24	0.808	0.985	1.137	1.151

Tabel 4. 6 Nilai rating dan penambahan lebar rata-rata sampel dengan cat epoksi

Titik	Pertambahan Lebar (mm)		
	Sampel 1	Sampel 2	Sampel 3
A	0.141	0.081	0.045
B	0.111	0.099	0.049
C	0.089	0.09	0.143
D	0.068	0.114	0.296
E	0.068	0.177	0.014
Rata-rata	0.0954	0.1122	0.1094
Rating	9	9	9

Perbandingan akan nilai pertambahan lebar dari setiap jenis coating dapat dilihat pada Gambar 4.3.



Gambar 4. 3 Perbandingan pertambahan lebar (mikron)

4.1.2. Pembahasan Hasil Uji Sembur Kabut Garam

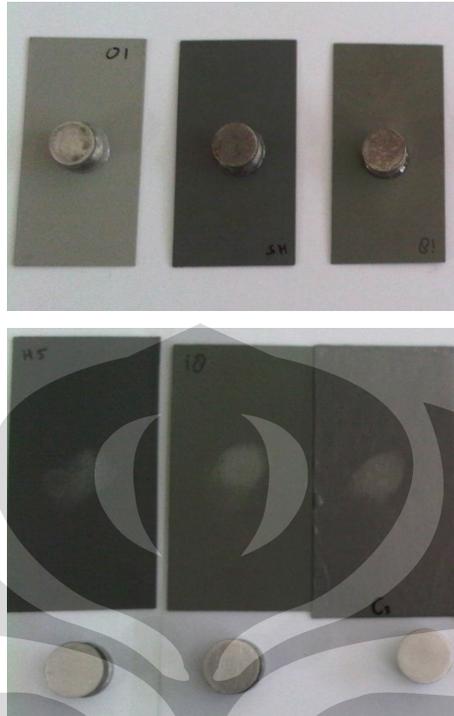
Nilai rating yang didapat berdasarkan ASTM D1654 untuk evaluasi cat dengan pengujian uji sembur kabut garam berdasarkan ASTM B117-03, dimana bila tidak mengalami penambahan goresan mendapatkan rating 10. Sedangkan pada pengujian kali ini didapatkan nilai rating 9, yaitu penambahan lebar goresan kurang dari 1 mm. Hal ini menunjukkan bahwa jumlah air dan oksigen yang masuk melewati lapisan masih dalam batas yang kurang cukup untuk merusak lapisan cat. Akan tetapi jika dilihat dari nilai penambahan lebar goresan rata-rata yang terbentuk, terlihat bahwa sampel uji dengan *zinc-rich* epoksi *coating* memiliki nilai penambahan lebar yang paling sedikit seperti yang ditunjukkan pada Gambar 4.3.

Dan bila dihubungkan dengan pengaruh luas permukaan dan daya adesi yang dihasilkan, perlakuan permukaan yang baik menghasilkan daya lekat yang kuat sehingga air dan oksigen kurang mampu menembus lapisan cat. Hal ini juga menunjukkan bahwa cat berpenetrasi dengan baik masuk kedalam pori atau celah profil permukaan yang terbentuk dengan perlakuan permukaan. Selain itu hal itu dipengaruhi sifat perlindungan oleh *coating* yaitu, proteksi katodik, yang berasal dari logam zinc pada *coating*, seperti yang dijelaskan pada Bab 2, yaitu mekanisme *sacrificial coating* yang dapat melindungi substratnya.

4.2. Uji Daya Lekat (*Adhesion*)

4.2.1. Hasil Uji Daya Lekat (*Adhesion*)

Uji daya lekat (*adhesi*) dilakukan untuk mengetahui daya lekat lapisan *organic* pada permukaan sampel uji, yang dapat dipengaruhi oleh pengikat an pigmennya . Standar yang digunakan untuk uji adesi ialah ASTM D 4541-02., dimana pengujiannya dinamakan *Pull-Off Test* yang menggunakan *Portable Adhesion Tester*.



Gambar 4. 4 Foto sampel sebelum dan sesudah uji daya lekat

Berdasarkan hasil pengujian uji daya lekat (*dolly test*) terhadap ketiga jenis *organic coating* dengan binder dan pigmen yang berbeda (epoksi, *zinc silicate*, dan *zinc-rich* epoksi) dihasilkan perbedaan terhadap nilai daya lekatnya. Uji daya lekat dilakukan dengan alat *Elcometer Model 106 Adhesion Tester Scale 1*. Untuk sampel dengan *zinc-rich* epoksi *coating* didapat nilai hasil rata-rata 1.4 Mpa.

Tabel 4. 7 Nilai daya lekat sampel dengan *zinc-rich* epoksi

<i>Zinc-Rich Epoksi</i>		
Sampel	Daya Lekat (lb/inch ²)	Daya Lekat (Mpa)
1	200	1.4
2	190	1.3
3	210	1.4
Rata Rata	200	1.4

Untuk sampel dengan *zinc silicate coating* didapat nilai hasil rata-rata 1.2 Mpa, seperti yang tertera pada Tabel 4.8, sedangkan untuk epoksi *coating* didapat nilai hasil rata-rata 1.0 Mpa yang ditunjukkan pada Tabel 4.9.

Tabel 4. 8 Nilai daya lekat sampel dengan *zinc silicate*

<i>Zinc Silicate</i>		
Sampel	Daya Lekat (lb/inch ²)	Daya Lekat (Mpa)
1	170	1.2
2	150	1.0
3	190	1.3
Rata Rata	170	1.2

Tabel 4. 9 Nilai daya lekat sampel dengan epoksi

<i>Epoksi</i>		
Sampel	Daya Lekat (lb/inch ²)	Daya Lekat (Mpa)
1	140	1.0
2	150	1.0
3	130	0.9
Rata Rata	140	1.0

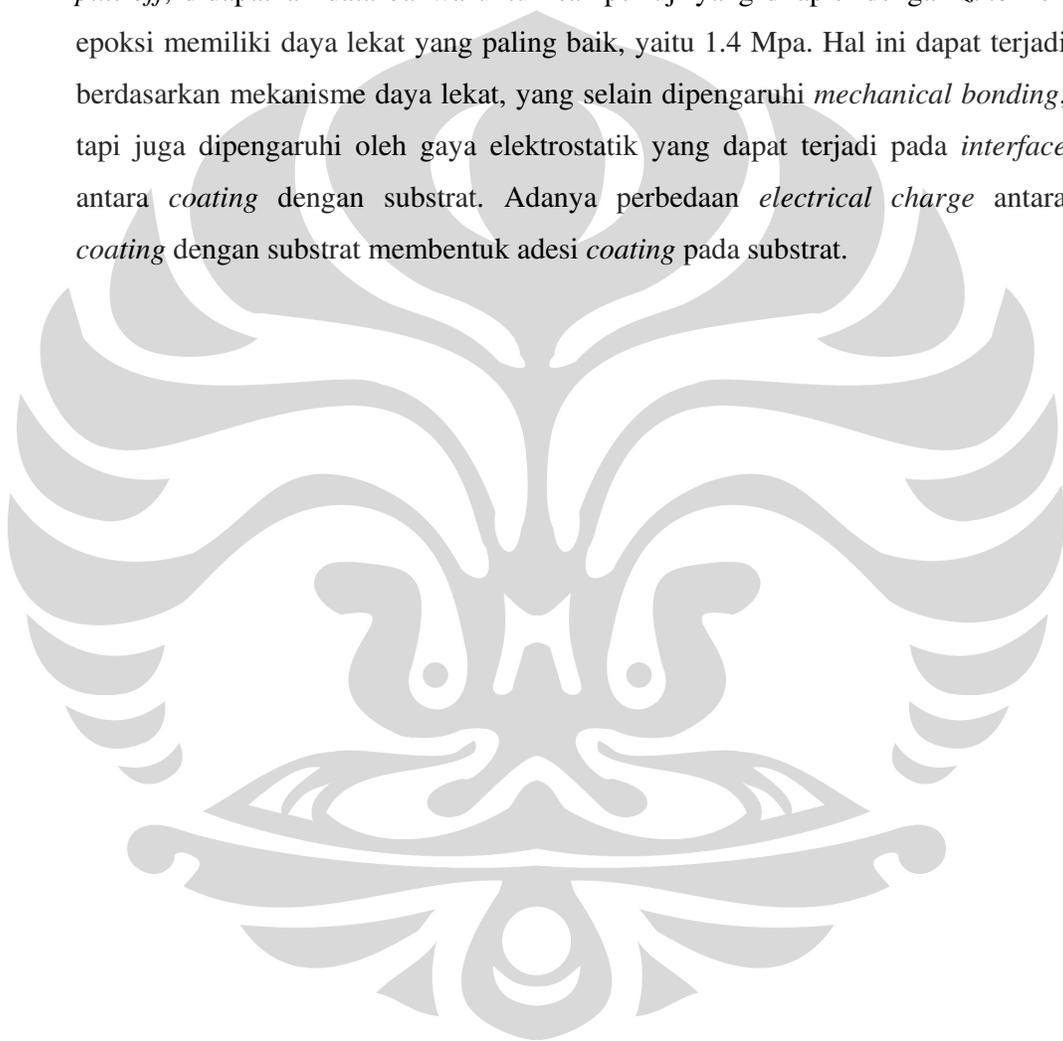
4.2.2. Pembahasan Hasil Uji Daya Lekat (*Adhesion*)

Preparasi permukaan yang telah dilakukan bertujuan untuk mendapatkan permukaan yang bebas dari kontaminan serta menciptakan kekasaran pada permukaan yang bebas dari kontaminan serta menciptakan kekasaran pada permukaan. Saat permukaan semakin kasar, maka pori/celah/lubang yang ada permukaan substrat semakin dalam sehingga saat pengaplikasian, *coating* dapat masuk ke dalam celah tersebut dan mengikat substrat dengan lebih baik. maka terjadilah *mechanical interlocking* antara *coating* dan substrat baja seperti yang telah dijelaskan pada Bab 2. Namun, saat *coating* tidak berpenetrasi dengan baik ke dalam substrat, maka kontak antar *coating* dan substrat menjadi kurang. Hal itu dapat menimbulkan *void* antara *coating* dan substrat di mana udara terjebak di dalamnya.

Selain *mechanical interlocking*, untuk terjadi adesi antara *coating* dengan substrat maka juga dibutuhkan *wetting* (pembahasan) oleh *coating* pada permukaan substrat. *Wetting* akan terjadi saat tegangan permukaan *liquid (coating)* lebih kecil dibandingkan tegangan permukaan substrat. Umumnya permukaan logam memiliki tegangan permukaan yang tinggi sehingga *coating* dapat membasahi permukaan substrat. Namun, saat permukaan substrat tidak

bersih (terdapat kontaminan), maka *wetting* tersebut dapat terganggu. Karena kontaminan memiliki tegangan permukaan yang rendah, maka proses *wetting* dari *coating* pada substrat akan lebih sulit [14]. Hal ini akan mempengaruhi adesi antara *coating* dengan substrat.

Pada percobaan ini ternyata setelah dilakukan uji adesi dengan metode *pull-off*, didapatkan data bahwa untuk sampel uji yang dilapisi dengan *zinc-rich* epoksi memiliki daya lekat yang paling baik, yaitu 1.4 Mpa. Hal ini dapat terjadi berdasarkan mekanisme daya lekat, yang selain dipengaruhi *mechanical bonding*, tapi juga dipengaruhi oleh gaya elektrostatis yang dapat terjadi pada *interface* antara *coating* dengan substrat. Adanya perbedaan *electrical charge* antara *coating* dengan substrat membentuk adesi *coating* pada substrat.



BAB 5

KESIMPULAN

Dari hasil penelitian dan pengamatan yang dilakukan, maka didapat kesimpulan sebagai berikut:

1. Tingkat korosifitas ketiga jenis pelapis (*coating*) pada substrat baja karbon rendah tidak jauh berbeda dan memiliki nilai rating yang sama pada lingkungan NaCl 5% selama 120 jam yaitu 9.
2. Pelapis (*coating*) dengan daya lekat yang paling baik, yaitu *zinc rich epoxy coating*, memiliki tingkat pertambahan kelebaran yang paling kecil pada uji sembur kabut garam yaitu rata-rata 51 μm , sedangkan *zinc silicate coating* rata-rata 87 μm dan *epoxy coating* rata-rata 106 μm .
3. *Zinc rich epoxy coating* memiliki daya lekat yang paling baik dengan nilai 1.4 Mpa, sedangkan *zinc silicate coating* memiliki daya lekat senilai 1.2 Mpa, dan *epoxy coating* memiliki daya lekat senilai 1.0 Mpa.
4. Pelapis (*coating*) dengan daya lekat paling baik, memiliki tingkat korositifitas yang paling rendah, ditandai dengan pertambahan kelebaran paling kecil pada uji sembur kabut garam.

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LAMPIRAN

Lampiran 1 – Data teknis cat

APPLICATION INSTRUCTIONS

For product description refer to product data sheet

PERATURAN TINDA TERAPAN
PERATURAN TINDA TERAPAN

Film thickness: Depending on the area of use, the typical dry film thickness may vary between 15 micron/0.6 mil and up to 50 micron/2 mils. This will alter amount of thinning required, spreading rate, drying time and recoating interval as described below. Indicated film thicknesses are as follows:

Shrink primer, Containers: When used as a shrink primer in container systems a typical dry film thickness is 15 micron/0.6 mil. Dilute 100-150% for airless spray, corresponding wet film thickness 60-75 micron/2.4-3 mils. (Note: In the case of a high degree of thinning, the mixture is to be stirred constantly and recirculate until all paint has been used)

Primer, container systems: When used as a primer in container systems the dry film thickness is approx. 30-40 micron/1.2-1.6 mils corresponding to 60-80 micron/2.4-3.2 mils wet film thickness. Dilute 0-10% for airless spray.

Spreading rates: The film thickness and the spreading rate are inversely proportional. By controlling the spreading rate, a check of the film thickness can be made.

Theoretical spreading rate calculated for undiluted paint:

15 micron/0.6 mils is 33.3 m²/litre or 1397 sq.ft./US gallon
 30 micron/1.2 mils is 16.7 m²/litre or 666 sq.ft./US gallon
 50 micron/2 mils is 10.0 m²/litre or 401 sq.ft./US gallon

Thinners: Airless spray: ~~Use minimum amount of thinner~~ **0-10%.** Lowest nozzle pressure should be used when highest amount of thinner is added. ~~Use minimum amount of thinner~~ **0-10%** is used for fast setting at application in shops. (Be aware of increased risk of dry spray)

Air spray and application by brush: Use only ~~minimum amount of thinner~~ **0-10%.**

Application Instruction Page 2/3



Physical data versus temperature:

Drying time and recoating interval vary with film thickness, drying/coating temperature and other exposure conditions.

Drying time and recoating interval vary with film thickness, drying/coating temperature and other exposure conditions.

in a dry film thicknesses of 30-40 micron/1.2-1.6 mils:

Surface temperature	10°C/50°F	20°C/63°F	30°C/86°F
Drying time, approx. minutes	1 hour	30	20
Coating time, approx. days	18	7	4
MINIMUM recoating interval related to later conditions of exposure:			
Interval for recoating with Minimum qualities			
Atmospheric, medium	40 minutes	15 minutes	7 minutes
Atmospheric, severe	2½ hours	1 hour	30 minutes
Immersion	Not relevant	Not relevant	Not relevant
Interval for recoating with Standard and Maximum qualities			
Atmospheric, medium	5 hours	2 hours	1 hour
Atmospheric, severe	8 hours	3 hours	1½ hours
Immersion*	15 hours	6 hours	3 hours
MAXIMUM recoating interval related to later conditions of exposure:			
Interval for recoating with Minimum qualities			
Atmospheric, medium	40 hours	16 hours	3 hours
Atmospheric, severe	30 hours	12 hours	6 hours
Immersion	Not relevant	Not relevant	Not relevant
Interval for recoating with Standard qualities			
Atmospheric, medium	10 days	4 days	2 days
Atmospheric, severe	5 days	2 days	1 day
Immersion	Not relevant	Not relevant	Not relevant
Interval for recoating with Maximum qualities			
Atmospheric, medium	None	None	None
Atmospheric, severe**	75 days	30 days	15 days
Immersion**	75 days	30 days	15 days
Interval for recoating with Minimum qualities			
Atmospheric, medium	25 days	10 days	5 days
Atmospheric, severe	7½ days	3 days	1½ day
Immersion	Not relevant	Not relevant	Not relevant

* NOT relevant for **Minimum** Qualities
 ** Depending on actual local conditions, extended maximum recoating intervals may apply. Please contact **3M** for further advice.

Application Instruction **Primer 3 / 3**



Minimum recoating interval

The minimum recoating interval: assume sufficient ventilation and correct application. In case of forced ventilation and/or drying at higher temperature, sufficient "Flash-off" time should be allowed for. For approx. 15 micron/1 mil dry film thickness count for minimum 10 minutes flash-off (at 20°C/68°F), for approximately 30 micron/1.0 mils minimum 15 minutes, for approximately 50 micron/3 mils minimum approximately 30 minutes.

The short minimum recoating intervals when recoated with ~~Primer 3 / 3~~ and ~~Primer 3 / 3~~ are only provided in case the finished paint system is through dry before exposure to the environment.

If the maximum recoating interval is exceeded, whatever the subsequent coat, roughening of the surface is necessary to ensure optimum intercoat adhesion.

Before recoating after exposure in contaminated environment, irrespective of recoating interval, clean the surface thoroughly e.g. by (high pressure) fresh water hosing and allow to dry. **It is very important that any possible "Ibc salts", "white rust", are removed.** Scrubbing with a stiff brush and plenty of water may be required.

Safety:

Handle with care. Before and during use, observe all safety labels on packaging and paint containers, consult ~~Primer 3 / 3~~ Material Safety Data Sheets and follow all local or national safety regulations. This goes for personal protection such as, but not limited to, protection of lungs, eyes and of the skin, medical treatment in case of swallowing the paint or in case of other direct contact with the paint. Take necessary precautions against possible risks of fire or explosions as well as protection of the environment. Apply only in well ventilated areas and ensure that adequate forced ventilation exists when applying paint in confined spaces or when the air is stagnant.

Issued:

May 2000
~~Primer 3 / 3~~ ~~Primer 3 / 3~~ 4/3

15360198.00C0004



PERMITS/REGULATIONS

APPROVED FORMULAS

Description: *Welding primer* is a two component polyamide cured zinc rich epoxy primer. It cures to a hard wearing and highly weather resistant coating. Offers cathodic protection of local mechanical damage.

Recommended use: For on line application on containers. Can be used as a zinc rich epoxy primer for other purposes according to separate painting specification.

Service temperatures: Maximum, dry: 160°C/320°F, however depending on the subsequent coat.

Certificates / Approvals: Approved as a welding primer by Lloyd's Register of Shipping.

Availability: Part of Group Assortment. Local availability subject to confirmation.

PHYSICAL CONSTANTS:

Colours/ Shade nos: Red grey/19830

Finish: Semi flat

Volume solids, %: 50 ± 1 ✓

Theoretical spreading rate: 12.5 m²/litre - 40 micron ✓
501 sq.ft./US gallon - 1.6 mils ✓

Flash point: 30°C/86°F

Specific gravity: 2.3 kg/litre - 19.2 lbs/US gallon

Surface dry: 30 minutes at 20°C/68°F (ISO 1517)

Dry to touch: 2 (repp.) hours at 20°C/68°F

Fully cured: 7 days at 20°C/68°F

V.O.C.: 455 g/litre - 3.8 lbs/US gallon

The physical constants stated are nominal data according to the *WIPAC* Group's approved formulas. They are subject to normal manufacturing tolerances and where stated, being standard deviation according to ISO 9542-1. Further reference is made to "Explanatory Notes" in the *WIPAC* Book.

APPLICATION DETAILS:

Mixing ratio for 15360: Base 15369 : Curing agent 95:10
4 : 1 by volume

Application method: Airless spray Air spray Brush
0.6450 (30%) OR 450 (50%) 0.8450 (5%)

Thinner (max.vol.): 3 hours (20°C/68°F) (airless spray)

Pot life: 6 hours (20°C/68°F) (brush)

Nozzle orifice: 0.17" - 0.21"

Nozzle pressure: 150 bar/2200 psi
(Airless spray data are indicative and subject to adjustment)

Cleaning of tools: *WIPAC* *WIPAC* *WIPAC*

Indicated film thickness, dry: 40 micron/1.6 mils (See REMARKS overleaf)

Indicated film thickness, wet: 75 micron/3 mils

Recoat interval, min: As per separate APPLICATION INSTRUCTIONS

Recoat interval, max: As per separate APPLICATION INSTRUCTIONS

Safety:

Handle with care. Before and during use, observe all safety labels on packaging and paint containers, consult *WIPAC* Material Safety Data Sheets and follow all local or national safety regulations. This goes for personal protection such as, but not limited to, protection of lungs, eyes and of the skin, medical treatment in case of swallowing the paint or in case of other direct contact with the paint. Take necessary precautions against possible risks of fire or explosions as well as protection of the environment. Apply only in well ventilated areas and ensure that adequate forced ventilation exists when applying paint in confined spaces or when the air is stagnant.

Issued:

May 2009



Peringatan Khusus

SURFACE PREPARATION:	Remove oil and grease, etc. with suitable detergent. Remove salt and other contaminants by (high pressure) fresh water cleaning. Abrasive blasting to Sa 2½ with a sharp-edged surface profile corresponding to Rugotest No. 3, BN9a, Kearn-Tator Comparator, 2.0 G/S or ISO Comparator, Medium (3).
APPLICATION CONDITIONS:	Use only where application and curing can proceed at temperatures above 10°C/50°F. The temperature of the surface must also be above these limits, respectively. The temperature of the paint itself should be 15°C/59°F or above. Apply only on a dry and clean surface with a temperature above the dew point to avoid condensation. In confined spaces provide adequate ventilation during application and drying.
SUBSEQUENT COAT:	According to specification.
REMARKS:	Certificate has been issued under the quality number 1536. Note: if used as anticorrosive protection under insulation of high temperature equipment it is very important that NO moisture can penetrate during slowdown periods. This to avoid risk of "wet corrosion" when the temperature rises.
Film thicknesses:	May be specified in another film thickness than indicated depending on purpose and area of use. This will alter spreading rate and may influence amount of thinning necessary, drying time, and recoating interval. Normal range is 15-50 micron/0.6-2.0 mils.
Recoating:	Recoating intervals related to later conditions of exposure; Consult separate APPLICATION INSTRUCTIONS. If the maximum recoating interval is exceeded, roughening of the surface is necessary to ensure intercoat adhesion. Before recoating after exposure in contaminated environment, clean the surface thoroughly by (high pressure) fresh water hosing and allow to dry. In addition, scrubbing with a stiff brush may be necessary to remove zinc corrosion products (white rust).
Note:	Peringatan Khusus is for professional use only.
ISSUED:	May 2000 - 1536019830C0005 Peringatan Khusus A/S

Zinc silicate

Ref No. 13

INTENDED USES An inorganic zinc rich primer for use in maintenance and new construction. Provides outstanding anticorrosive protection. Suitable for use with a wide range of high performance topcoats.

PRODUCT DESCRIPTION Two pack, self curing, solvent based zinc ethyl silicate. Excellent corrosion resistance. Good abrasion resistance which minimises mechanical damage. Conforms to BS5493:EP2A. Compiles with Shell Specification VI (g).

PRODUCT INFORMATION

Colour	Grey.
Volume Solids	63%.
Mix Ratio	1 : 2.57 by volume.
Flash Point	Greater than 13°C for liquid base and mixed paint.
Typical Thickness	75 microns dry equivalent to 119 microns wet.
Theoretical Coverage	8.4 m ² /litre (at stated volume solids and 75 microns dry film thickness).
Practical Coverage	Allow appropriate loss factors.
Dry Temperature	400°C
Resistance	(540°C when topcoated with Intertherm 50).

APPLICATION DETAILS

Method of Application	Airless spray, Conventional spray.
Thinner	Not normally required. If necessary use GTA803.
Cleaner	GTA803.
Pot Life	5°C - 8 hours, 23°C - 4 hours, 35°C - 2 hours.

Drying Time	Overcoating Interval Minimum by organic topcoats			
	Touch Dry	Hard Dry	Minimum	Maximum
Substrate Temperature				
5°C	30 minutes	4 hours	16 hours	Indefinite*
25°C	20 minutes	2 hours	16 hours	Indefinite*
35°C	10 minutes	2 hours ✓	16 hours	Indefinite*

* See Limitations.

Zinc silicate

Ref No. 13

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PRODUCT INFORMATION

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Typical Thickness	75 microns dry equivalent to 119 microns wet.
Theoretical Coverage	8.4 m ² /litre (at stated volume solids and 75 microns dry film thickness).
Practical Coverage	Allow appropriate loss factors.
Dry Temperature	400°C
Resistance	(540°C when topcoated with Intertherm 50).

APPLICATION DETAILS

Method of Application	Airless spray, Conventional spray.
Thinner	Not normally required. If necessary use GTA803.
Cleaner	GTA803.
Pot Life	5°C - 8 hours, 23°C - 4 hours, 35°C - 2 hours.

Drying Time	Overcoating Interval Minimum by organic topcoats			
	Touch Dry	Hard Dry	Minimum	Maximum
Substrate Temperature				
5°C	30 minutes	4 hours	16 hours	Indefinite*
25°C	20 minutes	2 hours	16 hours	Indefinite*
35°C	10 minutes	2 hours ✓	16 hours	Indefinite*

* See limitations.

Zinc silicate

SURFACE PREPARATION

Oil and grease should be removed in accordance with SSPC-SP1 solvent cleaning. Where necessary remove weld spatter, and smooth weld seams or sharp edges. The surface to be coated must be clean and dry.

Abrasive Blast Cleaning:

Abrasive blast clean to Sa2½ ISO 8501-1:1988 (Swedish Standard SIS 05 59 00). Surface defects revealed by the blast cleaning process should be ground, filled or treated in the appropriate manner.

Apply ~~Interzinc 22~~ to surfaces prepared in accordance with the specified visual ISO/Swedish Standard. If oxidation has occurred the surface should be reblasted to the specified standard.

Shop Primed Steelwork

~~Interzinc 22~~ is suitable for application to steelwork freshly coated with Interplate 11 when suitably prepared.

Weld seams and damaged areas should be blast cleaned to Sa2½ ISO 8501-1:1988 (Swedish Standard SIS 05 59 00).

If the zinc shop primer shows extensive or widely scattered breakdown or excessive zinc corrosion product overall sweep blasting will be necessary. Other types of shop primer will require complete removal by blast cleaning.

At high relative humidity and 15°C Interzinc 22 should meet ASTM D4752 MEK rub test after 24 hours.

METHOD OF APPLICATION

Add the QHA027 powder to the QHA028 liquid whilst stirring with a mechanical agitator. Do not add liquid to powder. Sieve before application. The paint reservoir should be equipped with a mechanical agitator.

Airless spray	Recommended	- Tip range 0.4-0.55 mm (17-21 thou). - Total output fluid pressure not less than 112 kg/cm ² (1,600 p.s.i.).
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Brush or Roller	Not recommended.	
Conventional spray	Suitable. Use any proprietary equipment with agitated container.	

LIMITATIONS

The minimum overcoating interval is dependent on the relative humidity. At relative humidities less than 65% the minimum recoat period will be at least 24 hours. The maximum recoat interval is normally indefinite but will be dependent on weather and environmental conditions. For self to self recoating consult International.

Before overcoating, ~~Interzinc 22~~ must be clean, dry and free from soluble zinc salts and excessive zinc corrosion products.

Over application of ~~Interzinc 22~~ causes mud-cracking.

SAFETY PRECAUTIONS

This product is intended for use only by professional applicators in industrial situations in accordance with the advice given on this sheet, the Health and Safety Data Sheet and the container (s) and should not be used without reference to the Health and Safety Data Sheet which International Protective Coatings has provided to its customers.

WORLDWIDE AVAILABILITY

It is the policy of International Protective Coatings to supply this product worldwide. However in certain countries product modifications may be required in order to comply with legislation or particular local conditions. Where this occurs, an alternative sales code and data sheet is used. Consult International Protective Coatings for details.

PRODUCT REFERENCE QHA028 / QHA027.

PACK SIZE	QHA027	1.4 litres in 7 litre steel container.
	QHA028	3.6 litres in 5 litre plastic container.

PRODUCT WEIGHT 2.80 kg/litre.

STORAGE Store in cool, dry conditions. Shelf life 6 months at 23°C.

Disclaimer

The information given in this sheet is not intended to be exhaustive and any person using the product for any purpose other than that specifically recommended in this sheet without first obtaining written confirmation from us as to the suitability of the product for the particular purpose does so at his own risk. Whilst we endeavour to ensure that all advice we give about the product (whether in this sheet or otherwise) is correct we have no control over either the quality or condition of the substrate or the many factors affecting the site and application of the product. Therefore unless we specifically agree in writing to do so, we do not accept any liability whatsoever or howsoever arising for the performance of the product or for any loss or damage (other than death or personal injury resulting from our negligence) arising out of the use of the product. The information contained in this sheet is liable to modification from time to time in the light of experience and our policy of continuous product development.

It is company policy to update this product documentation every two years unless change occur which necessitate an update prior to that date. It is the user's responsibility to check that this sheet is current prior to using the product. Issued date June 1996.



**INTERNATIONAL
PROTECTIVE
COATINGS**

Lampiran 2 – Standar preparasi permukaan

INTERNATIONAL STANDARD

ISO 8501-1: 1988 (E)

Preparation of steel substrates before application of paints and related products – Visual assessment of surface cleanliness

Part 1:

Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings

0 Introduction

The performance of protective coatings of paint and related products applied to steel is significantly affected by the state of the steel surface immediately prior to painting. The principal factors that are known to influence this performance are:

- a) the presence of rust and mill scale;
- b) the presence of surface contaminants, including salts, dust, oils and greases;
- c) the surface profile.

International Standards ISO 8501, ISO 8502 and ISO 8503 have been prepared to provide methods of assessing these factors, while ISO 8504 provides guidance on the preparation methods that are available for cleaning steel substrates, indicating the capabilities of each in attaining specified levels of cleanliness.

These International Standards do not contain recommendations for the protective coating systems to be applied to the steel surface. Neither do they contain recommendations for the surface quality requirements for specific situations even though surface quality can have a direct influence on the choice of protective coating to be applied and on its performance. Such recommendations are found in other documents such as national standards and codes of practice. It will be necessary for users of these International Standards to ensure that the qualities specified are:

- compatible and appropriate both for the environmental conditions to which the steel will be exposed and for the protective coating system to be used;
- within the capability of the cleaning procedure specified.

The four International Standards referred to above deal with the following aspects of preparation of steel substrates:

- ISO 8501 – *Visual assessment of surface cleanliness;*

ISO 8501-1 : 1988 (E)

ISO 8502 — Tests for the assessment of surface cleanliness;

ISO 8503 — surface roughness characteristics of blast-cleaned steel substrates;

ISO 8504 — surface preparation methods.

Each of these International Standards is in turn divided into separate parts.

This part of ISO 8501 identifies four levels (designated as "rust grades") of mill scale and rust that are commonly found on surfaces of uncoated erected steel and steel held in stock. It also identifies certain degrees of visual cleanliness (designated as "preparation grades") after surface preparation of uncoated steel surfaces and of steel surfaces after overcoating level of any previous coating. These levels of visual cleanliness are related to the common methods of surface cleaning that are used prior to painting.

This part of ISO 8501 is intended to be a tool for visual assessment of rust grades and of preparation grades. It includes 28 representative photographic examples.

NOTES

1. Twenty-four of the photographs originate from the Swedish standard SIS 05 59 00 (1967), *Pictorial surface preparation standards for painting steel surfaces*, which is superseded by this part of ISO 8501 (see annex A). The other four photographs originate from the German standard DIN 55 926 Part 4 Supplement 1 (August 1978), *Protection of steel structures from corrosion by organic and inorganic coatings; preparation and testing of surfaces; photographic standards*.

Originally SIS 05 59 00 was developed by the Swedish Corrosion Institute in co-operation with the American Society for Testing and Materials (ASTM) and the Steel Structures Painting Council (SSPC), USA. There are a number of national standards based on SIS 05 59 00, such as DIN 55 926 Part 4 (1977), TGL 18730/02 (1977), DS 2019 (1967), AS 1627, Part 9-1974, ASTM D 2200-67 (1960) and SSPC-Vis 1-82 T. In addition, there are other standards that have a similar layout, for example JSRA SPSS-1975, but which are less widely used and therefore were not taken into account.

The reasons for selecting the essential elements of SIS 05 59 00, including its format, are as follows:

- SIS 05 59 00 is already used on a world-wide scale;
- the creation of a completely new set of photographs would be costly and would not necessarily introduce any corresponding improvements;
- previous and current documents relating to this established system of rust grades and preparation grades could continue to be used in the future without amendment and without confusion;
- the A5 (pocket) size is convenient to handle and to refer to on site.

This part of ISO 8501 represents a slight extension of earlier editions of SIS 05 59 00 in that it is applicable also to surfaces that show residues of adhering paint and other foreign matter in addition to mill scale and rust.

ISO 8501-1 : 1988 (E)

2 This part of ISO 8501 contains the text in the three*official languages of ISO, namely English, French and Russian. It also contains the following annexes giving the equivalent text in other languages, published under the responsibility of the respective body indicated :

Annex A : Swedish (SIS : the text is the 1988 edition of the Swedish standard SS 05 59 00)

Annex B : German (DIN)

Annex C : Dutch (NNI)

Annex D : Italian (UNI)

Annex E : Spanish (AENOR)

Annex F : Portuguese (IPQ)

Annex G : Arabic (ASMO)

Annex H : Japanese (JISC)

Annex J : Chinese (CSBS)

1 Scope and field of application

This part of ISO 8501 specifies a series of rust grades and preparation grades of steel surfaces (see clauses 3 and 4, respectively). The various grades are defined by written descriptions together with photographs that are representative examples within the tolerance for each grade as described in words.

It is applicable to hot-rolled steel surfaces prepared for painting by methods such as blast-cleaning, hand and power tool cleaning and flame cleaning although these methods rarely lead to comparable results. Essentially, these methods are intended for hot-rolled steel, but blast-cleaning methods, in particular, could also be used on cold-rolled steel of sufficient thickness to withstand any deformation caused by the impact of the abrasive or the effects of power tool cleaning.

This part of ISO 8501 is applicable also to steel substrates that show residues of firmly adhering paint and other foreign matter (see note 2 to 4.1) in addition to residual mill scale.

NOTE — The preparation grades of previously painted steel surfaces after only localized removal of paint coatings form the subject of ISO 8501-2.

It relates the cleanliness of the surface to its visual appearance. In many instances, this is sufficient for the purpose but for coatings likely to be exposed to severe environments, such as water immersion and continuous condensation conditions, consideration should be given to testing for soluble salts and other invisible contaminants on the visually clean surface by the physical and chemical methods which form the subjects of the various parts of ISO 8502. The roughness characteristics of the surface should also be considered by reference to ISO 8503.

ISO 8501-1: 1988 (E)

2 References

ISO 8501-2, *Preparation of steel substrates before application of paints and related products — Visual assessment of surface cleanliness — Part 2: Preparation grades of previously coated steel substrates after localized removal of previous coatings.*¹⁾

ISO 8502, *Preparation of steel substrates before application of paints and related products — Tests for the assessment of surface cleanliness.*¹⁾

ISO 8503, *Preparation of steel substrates before application of paints and related products — Surface roughness characteristics of blast-cleaned steel substrates.*

ISO 8504, *Preparation of steel substrates before application of paints and related products — Surface preparation methods*

— Part 2: Abrasive blast cleaning.¹⁾

— Part 3: Hand and power tool cleaning.¹⁾

3 Rust grades

Four rust grades, designated A, B, C and D respectively, are specified. The rust grades are defined by written descriptions together with representative photographic examples (see clause 6).

A Steel surface largely covered with adhering mill scale but little, if any, rust.

B Steel surface which has begun to rust and from which the mill scale has begun to flake.

C Steel surface on which the mill scale has rusted away or from which it can be scraped, but with slight pitting visible under normal vision.

D Steel surface on which the mill scale has rusted away and on which general pitting is visible under normal vision.

4 Preparation grades

4.1 General

A number of preparation grades, indicating the method of surface preparation and the degree of cleaning, are specified. The preparation grades are defined (see 4.2, 4.3 and 4.4) by written descriptions of the surface appearance after the cleaning operation, together with representative photographic examples (see clause 6).

¹⁾ To be published.

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Each preparation grade is designated by the appropriate letters "Sa", "St" or "Fl" to indicate the type of cleaning method used. The number following, if any, indicates the degree of cleaning from mill scale, rust and previous coatings.

The photographs are designated by the original rust grade before cleaning and the designation of the preparation grade, for example B Sa 2 1/2.

NOTES

1. The term "foreign matter" used in 4.2, 4.3 and 4.4 may include water-soluble salts and welding residues. These contaminants cannot be completely removed from the surface by dry blast-cleaning, hand and power tool cleaning or flame cleaning; wet blast-cleaning should be used.
2. Mill scale, rust or a paint coating is considered to be poorly adhering if it can be removed by lifting with a blunt putty knife.

4.2 Blast-cleaning, Sa

Surface preparation by blast-cleaning is designated by the letters "Sa".

Prior to blast-cleaning, any heavy layers of rust shall be removed by chipping. Visible oil, grease and dirt shall also be removed.

After blast-cleaning, the surface shall be cleaned from loose dust and debris.

NOTE — For descriptions of surface preparation methods by blast-cleaning, including treatment prior to, and after, the blast-cleaning procedure, see ISO 8504-2.

Sa 1 Light blast-cleaning

When viewed without magnification, the surface shall be free from visible oil, grease and dirt, and from poorly adhering mill scale, rust, paint coatings and foreign matter (see note 2 to 4.1). See photographs B Sa 1, C Sa 1 and D Sa 1.

Sa 2 Thorough blast-cleaning

When viewed without magnification, the surface shall be free from visible oil, grease and dirt, and from most of the mill scale, rust, paint coatings and foreign matter. Any residual contamination shall be firmly adhering (see note 2 to 4.1). See photographs B Sa 2, C Sa 2 and D Sa 2.

Sa 2 1/2 Very thorough blast cleaning

When viewed without magnification, the surface shall be free from visible oil, grease and dirt, and from mill scale, rust, paint coatings and foreign matter. Any remaining traces of contamination shall show only as slight stains in the form of spots or stripes. See photographs A Sa 2 1/2, B Sa 2 1/2, C Sa 2 1/2 and D Sa 2 1/2.

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Sa 3 Blast-cleaning to visually clean steel

When viewed without magnification, the surface shall be free from visible oil, grease and dirt, and shall be free from mill scale, rust, paint coatings and foreign matter. It shall have a uniform metallic colour. See photographs A Sa 3, B Sa 3, C Sa 3 and D Sa 3.

4.3 Hand and power tool cleaning, St

Surface preparation by hand and power tool cleaning, such as scraping, wire-brushing, machine-brushing and grinding, is designated by the letters "St".

Prior to hand and power tool cleaning, any heavy layers of rust shall be removed by chipping. Visible oil, grease and dirt shall also be removed.

After hand and power tool cleaning, the surface shall be cleaned from loose dust and debris.

NOTES

- For descriptions of surface preparation methods by hand and power tool cleaning, including treatment prior to, and after, the hand and power tool cleaning procedure, see ISO 8504-3.
- Preparation grade St 1 is not included as it would correspond to a surface unsuitable for painting.

St 2 Thorough hand and power tool cleaning

When viewed without magnification, the surface shall be free from visible oil, grease and dirt, and from poorly adhering mill scale, rust, paint coatings and foreign matter (see note 2 to 4.1). See photographs B St 2, C St 2 and D St 2.

St 3 Very thorough hand and power tool cleaning

As for St 2, but the surface shall be treated much more thoroughly to give a metallic sheen arising from the metallic substrate. See photographs B St 3, C St 3 and D St 3.

4.4 Flame cleaning, F1

Surface preparation by flame cleaning is designated by the letters "F1".

NOTE - Flame cleaning includes final power tool wire-brushing to remove the products of the cleaning process; hand wire-brushing does not achieve a satisfactory surface for painting.

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Prior to flame cleaning, any heavy layers of rust shall be removed by chipping.

After flame cleaning, the surface shall be cleaned by power tool wire brushing.

Fl Flame cleaning

When viewed without magnification, the surface shall be free from mill scale, rust, paint coatings and foreign matter. Any remaining residues shall show only as a discoloration of the surface (shades of different colours). See photographs A Fl, B Fl, C Fl and D Fl.

5 Procedure for visual assessment of steel substrates

Either in good diffuse daylight or in equivalent artificial illumination, examine the steel surface and compare it with each of the photographs (see clause 6), using normal vision. Place the appropriate photograph close to, and in the plane of, the steel surface to be assessed.

For rust grades, record the assessment as the worst grade that is evident. For preparation grades, record the assessment as that grade nearest in appearance to that of the steel surface.

NOTES

1 In addition to the type of cleaning method used, for example dry blast-cleaning using a particular type of abrasive, the following factors can influence the result of the visual assessment:

- a) initial state of the steel surface other than any of the standard rust grades A, B, C and D;
- b) colour of the steel itself;
- c) regions of differing roughness, resulting from differential corrosion attack or uneven removal of material;
- d) surface irregularities such as dents;
- e) marks from tools;
- f) uneven lighting;
- g) shadowing of the surface profile caused by angled projection of abrasive;
- h) embedded abrasives.

2 For previously painted surfaces that have been prepared for renewal painting, only photographs with rust grade designations D or C (for example : D Sa 2½ or C Sa 2½) may be used for the visual assessment. The choice (for example between D Sa 2½ and C Sa 2½) depends on the degree of pitting.

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6 Photographs

Twenty-eight representative photographic examples for comparison with steel substrates are appended.

These photographs, which are not magnified, are copies that have been reproduced by a special technique whereby the colour print is applied to the back of plastics sheets. To prevent the specimens from being scratched, paper leaves have been inserted between the plastics sheets. For ease of manufacture, the plastics sheets do not carry page numbers. For convenience in use, the photographs are displayed in the order shown in the figure.

Four photographs relate specifically to the rust grades A, B, C and D (see clause 3).

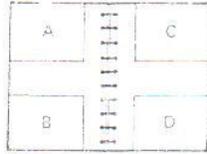
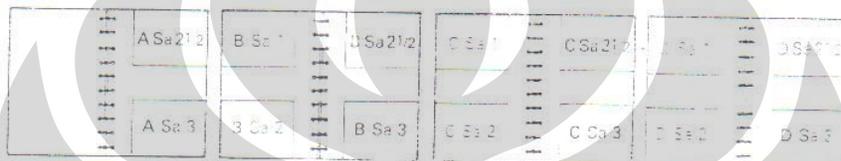
Twenty-four photographs, A Sa 2½ to D Fl, relate specifically to the preparation grades obtained by dry blast-cleaning, by hand and power tool cleaning, and by flame cleaning (see clause 4). Other methods, such as wet blast-cleaning, produce surfaces that may differ in appearance, colour, etc., but the photographs can still be used to give an indication of the preparation grade.

Fourteen photographs, A Sa 2½ to D Sa 3, show steel surfaces that have been subjected to dry blast-cleaning with abrasives containing quartz sand. The use of such abrasives in enclosed areas is prohibited in many countries except under strictly controlled conditions. Therefore abrasives of other types (and hence colour) are often used for dry blast-cleaning. These abrasives may produce a different surface appearance even after meticulous cleaning of the blast-cleaned surface.

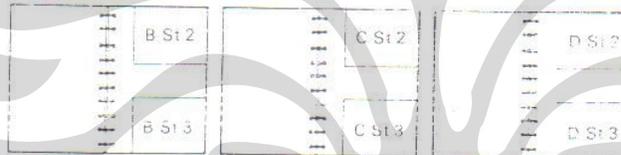
There are no photographs representing A Sa 1, A Sa 2, A St 2 or A St 3 because these preparation grades are not achievable and the existing photographs are sufficiently indicative.

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Rust grades

Preparation grades
Blast-cleaning

Hand and power tool cleaning



Flame cleaning



Figure — Layout and sequence of the appended representative photographic examples

Lampiran 3 – Data aplikasi cat

DFT *Zinc Silicate*

	Sisi Depan			Rata	Sisi Belakang			Rata
i-1	111	126	113	117	102	105	108	105
i-2	94	113	115	107	131	119	114	121
i-3	104	100	104	103	93	81	88	87
i-4	96	106	101	101	100	100	107	102
i-5	86	108	85	93	91	95	99	95
i-6	96	95	96	96	101	98	101	100
i-7	98	99	107	102	141	88	85	105
i-8	100	103	109	104	94	92	130	105
	Rata-rata			103	Rata-rata			103

DFT *Zinc Epoxy*

	Sisi Depan			Rata	Sisi Belakang			Rata
h-1	88	131	100	106	148	165	155	156
h-2	117	120	118	118	102	96	100	99
h-3	105	124	118	116	104	102	97	101
h-4	97	99	106	101	111	122	114	116
h-5	99	103	103	102	115	120	109	115
h-6	121	129	117	122	109	114	120	114
h-7	123	133	127	128	96	103	110	103
h-8	113	125	109	116	114	111	105	110
	Rata-rata			114	Rata-rata			114

DFT *Epoxy*

	Sisi Depan			Rata	Sisi Belakang			Rata
1,1	99	96	105	100	101	105	95	100
1,2	101	101	101	101	112	95	94	100
1,3	110	116	104	110	94	104	93	97
1,4	97	95	94	95	92	93	98	94
1,5	112	107	102	107	105	94	94	98
1,6	93	91	92	92	109	104	102	105
1,7	96	103	94	98	102	104	101	102
	Rata-rata			100	Rata-rata			100

Lampiran 4 – Standar pengujian sembur kabut garam (*salt spray*)

Designation: B 117 – 03

Standard Practice for Operating Salt Spray (Fog) Apparatus¹

This standard is issued under the fixed designation B 117; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last revision. A superscripted epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This practice covers the apparatus, procedure, and conditions required to create and maintain the salt spray (fog) test environment. Suitable apparatus which may be used is described in Appendix X1.

1.2 This practice does not prescribe the type of test specimen or exposure periods to be used for a specific product, nor the interpretation to be given to the results.

1.3 The values stated in SI units are to be regarded as standard. The inch-pound units in parentheses are provided for information and may be approximate.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards²

- B 368 Method for Coppers/Accelerated Acetic Acid-Salt Spray (Fog) Testing (CASS Test)²
- D 669 Practice for Preparation of Cold-Rolled Steel Panels for Testing Paint, Varnish, Conversion Coatings, and Related Coating Products³
- D 1193 Specification for Reagent Water⁴
- D 1654 Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments⁵
- E 70 Test Method for pH of Aqueous Solutions with the Glass Electrode⁶
- E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method⁷

¹ This practice is under the jurisdiction of ASTM Committee F10 on Corrosion of Metals and is the direct responsibility of Subcommittee G01.35 on Laboratory Corrosion Tests.

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² Annual Book of ASTM Standards, Vol 05.06.

³ Annual Book of ASTM Standards, Vol D 07.01.

⁴ Annual Book of ASTM Standards, Vol E 01.01.

⁵ Annual Book of ASTM Standards, Vol 15.25.

⁶ Annual Book of ASTM Standards, Vol 14.07.

G 85 Practice for Modified Salt Spray (Fog) Testing⁷

3. Significance and Use

3.1 This practice provides a controlled corrosive environment which has been utilized to produce relative corrosion resistance information for specimens of metals and coated metals exposed in a given test chamber.

3.2 Prediction of performance in natural environments has seldom been correlated with salt spray results when used as stand-alone data.

3.2.1 Correlation and extrapolation of corrosion performance based on exposure to the test environment provided by this practice are not always predictable.

3.2.2 Correlation and extrapolation should be considered only in cases where appropriate corroborating long-term atmospheric exposures have been conducted.

3.3 The reproducibility of results in the salt spray exposure is highly dependent on the type of specimens tested and the evaluation criteria selected, as well as the control of the operating variables. In any testing program, sufficient replicates should be included to establish the variability of the results. Variability has been observed when similar specimens are tested in different fog chambers even though the testing conditions are nominally similar and within the ranges specified in this practice.

4. Apparatus

4.1 The apparatus required for salt spray (fog) exposure consists of a fog chamber, a salt solution reservoir, a supply of suitably conditioned compressed air, one or more atomizing nozzles, specimen supports, provision for heating the chamber, and necessary means of control. The size and detailed construction of the apparatus are optional, provided the conditions obtained meet the requirements of this practice.

4.2 Drops of solution which accumulate on the ceiling or cover of the chamber shall not be permitted to fall on the specimens being exposed.

⁷ Annual Book of ASTM Standards, Vol G 03.02.


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4.3 Drops of solution which fall from the specimens shall not be returned to the solution reservoir for respraying.

4.4 Material of construction shall be such that it will not affect the corrosiveness of the fog.

4.5 All water used for this practice shall conform to Type IV water in Specification D 1193 (except that for this practice limits for chlorides and sodium may be ignored). This does not apply to running tap water. All other water will be referred to as reagent grade.

5. Test Specimens

5.1 The type and number of test specimens to be used, as well as the criteria for the evaluation of the test results, shall be defined in the specifications covering the material or product being exposed or shall be mutually agreed upon between the purchaser and the seller.

6. Preparation of Test Specimens

6.1 Specimens shall be suitably cleaned. The cleaning method shall be optional depending on the nature of the surface and the contaminants. Care shall be taken that specimens are not recontaminated after cleaning by excessive or careless handling.

6.2 Specimens for the evaluation of paints and other organic coatings shall be prepared in accordance with applicable specification(s) for the material(s) being exposed, or as agreed upon between the purchaser and the supplier. Otherwise, the test specimens shall consist of steel meeting the requirements of Practice D 609 and shall be cleaned and prepared for coating in accordance with the applicable procedure of Practice D 609.

6.3 Specimens coated with paints or nonmetallic coatings shall not be cleaned or handled excessively prior to test.

6.4 Whenever it is desired to determine the development of corrosion from an abraded area in the paint or organic coating, a scratch or scribed line shall be made through the coating with a sharp instrument so as to expose the underlying metal before testing. The conditions of making the scratch shall be as defined in Test Method D 1654, unless otherwise agreed upon between the purchaser and the seller.

6.5 Unless otherwise specified, the cut edges of plated, coated, or duplex materials and areas containing identification marks or in contact with the racks or supports shall be protected with a suitable coating stable under the conditions of the practice.

Note 1—Should it be desirable to cut test specimens from parts or from galvanized, painted, or otherwise coated steel sheet, the cut edges shall be protected by coating them with paint, wax, tape, or other effective media so that the development of a galvanic effect between such edges and the adjacent plated or otherwise coated metal surfaces is prevented.

7. Position of Specimens During Exposure

7.1 The position of the specimens in the salt spray chamber during the test shall be such that the following conditions are met:

7.1.1 Unless otherwise specified, the specimens shall be supported or suspended between 15 and 30° from the vertical and preferably parallel to the principal direction of flow of fog through the chamber, based upon the dominant surface being tested.

7.1.2 The specimens shall not contact each other or any metallic material or any material capable of acting as a wick.

7.1.3 Each specimen shall be placed to permit unencumbered exposure to the fog.

7.1.4 Salt solution from one specimen shall not drip on any other specimen.

Note 2—Suitable materials for the construction or coating of racks and supports are glass, rubber, plastic, or suitably coated wood. Bare metal shall not be used. Specimens shall preferably be supported from the bottom or the side. Slotted wooden strips are suitable for the support of flat panels. Suspension from glass hooks or waxed string may be used as long as the specified position of the specimens is obtained, if necessary by means of secondary support at the bottom of the specimens.

8. Salt Solution

8.1 The salt solutions shall be prepared by dissolving 5 ± 1 parts by mass of sodium chloride in 95 parts of water conforming to Type IV water in Specification D 1193 (except that for this practice limits for chlorides and sodium may be ignored). Careful attention should be given to the chemical content of the salt. The salt used shall be sodium chloride with not more than 0.3 % by mass of total impurities. Halides (Bromide, Fluoride, and Iodide) other than Chloride shall constitute less than 0.1 % by mass of the salt content. Copper content shall be less than 0.3 ppm by mass. Sodium chloride containing anti-caking agents shall not be used because such agents may act as corrosion inhibitors. See Table 1 for a listing of these impurity restrictions. Upon agreement between the purchaser and the seller, analysis may be required and limits established for elements or compounds not specified in the chemical composition given above.

TABLE 1 Maximum Allowable Limits for Impurity Levels in Sodium Chloride^{A,B}

Impurity Description	Allowable Amount
Total Impurities	< 0.3 %
Halides (Bromide, Fluoride and Iodide) excluding Chloride	< 0.1 %
Copper	< 0.3 ppm
Anti-caking Agents	0.0 %

^A A common formula used to calculate the amount of salt required by racks to achieve a 5 % salt solution of a known mass of water is:

$$.053 X \text{ Mass of Water} = \text{Mass of NaCl required}$$

The ratio of water is 7 g per 1 ml. To calculate the mass of salt required in grams to mix 1 L of a 5 % salt solution, multiply .053 by 1000 g (98.27 oz), the mass of 1 L of water. This formula yields a result of 53 g (1.87 oz.) of NaCl required for each liter of water to achieve a 5 % salt solution by mass.

The 0.053 multiplier for the sodium chloride used above is derived by the following:

$$1000 \text{ g/mass of a full L of water divided by } 0.96$$

(water is only 96 % of the total mixture by mass) yields 1053 g

This 1053 g is the total mass of the mixture of one L of water with a 5% sodium chloride concentration. 1053 g minus the original weight of the L of water, 1000 g, yields 53 g for the weight of the sodium chloride. 53 g of total sodium chloride divided by the original 1000 g of water yields a 0.053 multiplier for the sodium chloride.

As an example, to mix the equivalent of 200 L (52.83 gal) of 5 % sodium chloride solution, mix 10.6 kg (23.37 lb) of sodium chloride into 200 L (52.83 gal) of water. 200 L of water weighs 200,000 g. 200,000 g of water x .053 (sodium chloride multiplier) = 10,600 g of sodium chloride, or 10.6 kg.

^B In order to ensure that the proper salt concentration was achieved when mixing the solution, it is recommended that the solution be checked with either a salimeter/hydrometer or specific gravity hydrometer. When using a salimeter/hydrometer, the measurement should be between 4 and 6 % at 26°C (77°F). When using a specific gravity hydrometer, the measurement should be between 1.0255 and 1.0400 at 26°C (77°F).

8.2 The pH of the salt solution shall be such that when atomized at 35°C (95°F) the collected solution will be in the pH range from 6.5 to 7.2 (Note 3). Before the solution is atomized it shall be free of suspended solids (Note 4). The pH measurement shall be made at 25°C (77°F) using a suitable glass pH-sensing electrode, reference electrode, and pH meter system in accordance with Test Method E 70.

NOTE 3—Temperature affects the pH of a salt solution prepared from water saturated with carbon dioxide at room temperature and pH adjustment may be made by the following three methods:

(1) When the pH of a salt solution is adjusted at room temperature, and atomized at 35°C (95°F), the pH of the collected solution will be higher than the original solution due to the loss of carbon dioxide at the higher temperature. When the pH of the salt solution is adjusted at room temperature, it is therefore necessary to adjust it below 6.5 so the collected solution after atomizing at 35°C (95°F) will meet the pH limits of 6.5 to 7.2. Take about a 50-ml. sample of the salt solution as prepared at room temperature, boil gently for 30 s., cool, and determine the pH. When the pH of the salt solution is adjusted to 6.5 to 7.2 by this procedure, the pH of the atomized and collected solution at 35°C (95°F) will come within this range.

(2) Heating the salt solution to boiling and cooling to 35°C (95°F) and maintaining it at 35°C (95°F) for approximately 48 h before adjusting the pH produces a solution the pH of which does not materially change when atomized at 35°C (95°F).

(3) Heating the water from which the salt solution is prepared to 35°C (95°F) or above, to expel carbon dioxide, and adjusting the pH of the salt solution within the limits of 6.5 to 7.2 produces a solution the pH of which does not materially change when atomized at 35°C (95°F).

NOTE 4—The freshly prepared salt solution may be filtered or decanted before it is placed in the reservoir, or the end of the tube leading from the solution to the atomizer may be covered with a double layer of cheesecloth to prevent plugging of the nozzle.

NOTE 5—The pH can be adjusted by additions of dilute HCl or aqueous grade hydrochloric acid or sodium hydroxide solutions.

9. Air Supply

9.1 The compressed air supply to the Air Saturator Tower shall be free of grease, oil, and dirt before use by passing through well-maintained filters. (Note 6) This air should be maintained at a sufficient pressure at the base of the Air Saturator Tower to meet the suggested pressures of Table 2 at the top of the Air Saturator Tower.

NOTE 6—The air supply may be freed from oil and dirt by passing it through a suitable oil/water extractor (that is commercially available) to stop any oil from reaching the Air Saturator Tower. Many oil/water extractors have an expiration indicator, proper preventive maintenance intervals should take these into account.

9.2 The compressed air supply to the atomizer nozzle or nozzles shall be conditioned by introducing it into the bottom of a tower filled with water. A common method of introducing the air is through an air dispersion device (X1.4.1). The level of the water must be maintained automatically to ensure adequate humidification. It is common practice to maintain the temperature in this tower between 46 and 49°C (114–121°F) to offset the cooling effect of expansion to atmospheric pressure during the atomization process. Table 2 in 9.3 of this practice shows the temperature, at different pressures, that are commonly used to offset the cooling effect of expansion to atmospheric pressure.

9.3 Careful attention should be given to the relationship of tower temperature to pressure since this relationship can have

a direct impact to maintaining proper collection rates (Note 7). It is preferable to saturate the air at temperatures well above the chamber temperature as insurance of a wet fog as listed in Table 2.

TABLE 2 Suggested Temperature and Pressure guideline for the top of the Air Saturator Tower for the operation of a test at 35°C (95°F)

Air Pressure, kPa	Temperature, °C	Air Pressure, PSI	Temperature, °F
83	46	12	114
90	47	14	117
110	48	16	119
124	49	18	121

NOTE 7—If the tower is run outside of these suggested temperature and pressure ranges to achieve proper collection rates as described in 10.2 of this practice, other means of verifying the proper corrosion rate in the chamber should be investigated, such as the use of control specimens (panels of known performance in the test conducted). It is preferred that control panels be provided that bracket the expected test specimen performance. The controls allow for the normalization of test conditions during repeated running of the test and will also allow comparisons of test results from different regions of the same test. (Refer to Appendix N3, Evaluation of Corrosive Conditions, for mass loss procedures).

10. Conditions in the Salt Spray Chamber

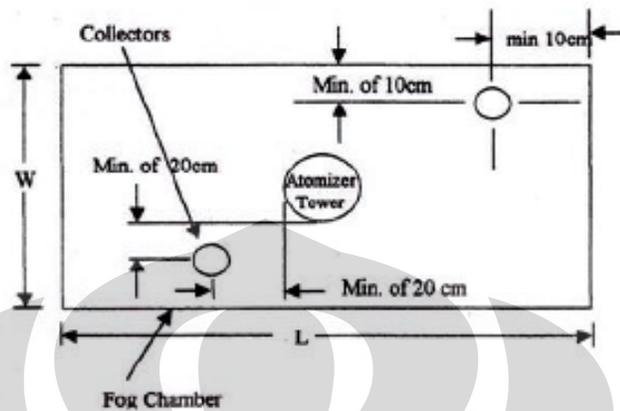
10.1 **Temperature**—The exposure zone of the salt spray chamber shall be maintained at $32 \pm 1.4 - 1.7^\circ\text{C}$ ($95 \pm 2 - 3^\circ\text{F}$). Each set point and its tolerance represents an operational control point for equilibrium conditions at a single location in the cabinet which may not necessarily represent the uniformity of conditions throughout the cabinet. The temperature within the exposure zone of the closed cabinet shall be recorded (Note 8) at least twice a day at least 7 h apart (except on Saturdays, Sundays, and holidays when the salt spray test is not interrupted for exposing, rearranging, or removing test specimens or to check and replenish the solution in the reservoir).

NOTE 8—A suitable method to record the temperature is by a continuous recording device or by a thermometer which can be read from outside the closed cabinet. The recorded temperature must be obtained with the salt spray chamber closed to avoid a false low reading because of wet-bulb effect when the chamber is open.

10.2 **Atomization and Quantity of Fog**—Place at least two clean fog collectors per atomizer tower within the exposure zone so that no drops of solution will be collected from the test specimens or any other source. Position the collectors in the proximity of the test specimens, one nearest to any nozzle and the other furthest from all nozzles. A typical arrangement is shown in Fig. 1. The fog shall be such that for each 80 cm^2 (12.4 in.^2) of horizontal collecting area, there will be collected from 1.0 to 2.0 mL of solution per hour based on an average run of at least 16 h (Note 9). The sodium chloride concentration of the collected solution shall be 5 ± 1 mass % (Notes 9+12). The pH of the collected solution shall be 6.5 to 7.2. The pH measurement shall be made as described in 8.2 (Note 3).

NOTE 9—Suitable collecting devices are glass or plastic funnels with

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Note—This figure shows a typical fog collector arrangement for a single atomizer tower cabinet. The same fog collector arrangement is also applicable for multiple atomizer tower and horizontal ("T" type) atomizer tower cabinet constructions as well.

FIG. 1 Arrangement of Fog Collectors

the stems inserted through stoppers into graduated cylinders, or crystallizing dishes, funnels, and dishes with a diameter of 16 cm (3.94 in.) have an area of about 80 cm² (12.4 in.²).

Note 10—A solution having a specific gravity of 1.0255 to 1.0400 at 25°C (77°F) will meet the concentration requirement. The sodium chloride concentration may also be determined using a suitable salinity meter (for example, utilizing a sodium ion-selective glass electrode) or colorimetrically as follows. Dilute 5 mL of the collected solution to 100 mL with distilled water and mix thoroughly; pipet a 10-mL aliquot into an evaporating dish or casserole, add 40 mL of distilled water and 1 mL of 1% potassium chromate solution (chloride-free) and dilute with 0.1 N silver nitrate solution to the first appearance of a permanent red coloration. A solution that requires between 3.4 and 5.1 mL of 0.1 N silver nitrate solution will meet the concentration requirements.

Note 11—Salt solutions from 2 to 6% will give the same results, though for uniformity the limits are set at 4 to 6%.

10.3 The nozzle or nozzles shall be so directed or baffled that none of the spray can impinge directly on the test specimens.

11. Continuity of Exposure

11.1 Unless otherwise specified in the specifications covering the material or product being tested, the test shall be continuous for the duration of the entire test period. Continuous operation implies that the chamber be closed and the spray operating continuously except for the short daily interruptions necessary to inspect, rearrange, or remove test specimens, to check and replenish the solution in the reservoir, and to make necessary recordings as described in Section 10. Operations shall be so scheduled that these interruptions are held to a minimum.

12. Period of Exposure

12.1 The period of exposure shall be as designated by the specifications covering the material or product being tested or as mutually agreed upon between the purchaser and the seller.

Note 12—Recommended exposure periods are to be as agreed upon between the purchaser and the seller, but exposure periods of multiples of 24 h are suggested.

13. Cleaning of Tested Specimens

13.1 Unless otherwise specified in the specifications covering the material or product being tested, specimens shall be tested as follows at the end of the test:

13.1.1 The specimens shall be carefully removed.

13.2 Specimens may be gently washed or dipped in clean running water not warmer than 38°C (100°F) to remove salt deposits from their surface, and then immediately dried.

14. Evaluation of Results

14.1 A careful and immediate examination shall be made as required by the specifications covering the material or product being tested or by agreement between the purchaser and the seller.

15. Records and Reports

15.1 The following information shall be recorded, unless otherwise prescribed in the specifications covering the material or product being tested:

15.1.1 Type of salt and water used in preparing the salt solution,

15.1.2 All readings of temperature within the exposure zone of the chamber,

15.1.3 Daily records of data obtained from each fog-collecting device including the following:

15.1.3.1 Volume of salt solution collected in millilitres per hour per 80 cm² (12.4 in.²),

15.1.3.2 Concentration or specific gravity at 35°C (95°F) of solution collected, and

15.1.3.3 pH of collected solution.


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- 15.2 Type of specimen and its dimensions, or number or description of part,
 15.3 Method of cleaning specimens before and after testing,
 15.4 Method of supporting or suspending article in the salt spray chamber,
 15.5 Description of protection used as required in 6.5,
 15.6 Exposure period,
 15.7 Interruptions in exposure, cause, and length of time, and

- 15.8 Results of all inspections.

Note 13—If any of the atomized salt solution which has not contacted the test specimens is returned to the reservoir, it is advisable to record the concentration or specific gravity of this solution also.

16. Keywords

- 16.1 controlled corrosive environment; corrosive conditions; determining mass loss; salt spray (fog) exposure

APPENDICES

(Nonmandatory Information)

XI. CONSTRUCTION OF APPARATUS

XI.1 Cabinets

XI.1.1 Standard salt spray cabinets are available from several suppliers, but certain pertinent accessories are required before they will function according to this practice and provide consistent control for duplication of results.

XI.1.2 The salt spray cabinet consists of the basic chamber, an air-saturator tower, a salt solution reservoir, atomizing nozzles, specimen supports, provisions for heating the chamber, and suitable controls for maintaining the desired temperature.

XI.1.3 Accessories such as a suitable adjustable baffle or central fog tower, automatic level control for the salt reservoir, and automatic level control for the air-saturator tower are pertinent parts of the apparatus.

XI.1.4 The size and shape of the cabinet shall be such that the atomization and quantity of collected solution is within the limits of this practice.

XI.1.5 The chamber shall be made of suitably inert materials such as plastic, glass, or stone, or constructed of metal and lined with impervious plastics, rubber, or epoxy-type materials or equivalent.

XI.1.6 All piping that contacts the salt solution or spray should be of inert materials such as plastic. Vent piping should be of sufficient size so that a minimum of back pressure exists and should be installed so that no solution is trapped. The exposed end of the vent pipe should be shielded from extreme air currents that may cause fluctuation of pressure or vacuum in the cabinet.

XI.2 Temperature Control

XI.2.1 The maintenance of temperature within the salt chamber can be accomplished by several methods. It is generally desirable to control the temperature of the surroundings of the salt spray chamber and to maintain it as stable as possible. This may be accomplished by placing the apparatus in a constant-temperature room, but may also be achieved by surrounding the basic chamber of a jacket containing water or air at a controlled temperature.

XI.2.2 The use of immersion heaters in an internal salt solution reservoir or within the chamber is detrimental where

heat losses are appreciable because of solution evaporation and radiant heat on the specimens.

XI.3 Spray Nozzles

XI.3.1 Satisfactory nozzles may be made of hard rubber, plastic, or other inert materials. The most commonly used type is made of plastic. Nozzles calibrated for air consumption and solution-atomized are available. The operating characteristics of a typical nozzle are given in Table XI.1.

XI.3.2 It can readily be seen that air consumption is relatively stable at the pressures normally used, but a marked reduction in solution sprayed occurs if the level of the solution is allowed to drop appreciably during the test. Thus, the level of the solution in the salt reservoir must be maintained automatically to ensure uniform fog delivery during the test.⁵

XI.3.3 If the nozzle selected does not atomize the salt solution into uniform droplets, it will be necessary to direct the spray at a baffle or wall to pick up the larger drops and prevent them from impinging on the test specimens. Pending a complete understanding of air-pressure effects, and so forth, it is important that the nozzle selected shall produce the desired

⁵ A suitable device for maintaining the level of liquid in either the saturator tower or reservoir of test solution may be designed by a local engineering group, or may be purchased from manufacturers of test cabinets as an accessory.

TABLE XI.1 Operating Characteristics of Typical Spray Nozzle

Siphon Height, cm	Air Flow, dm ³ /min				Solution Consumption, cm ³ /h			
	Air Pressure, kPa				Air Pressure, kPa			
4	34	69	103	138	34	69	103	138
8	19	26.5	31.5	36	2100	2760	3284	4256
12	19	26.5	31.5	36	636	2760	3720	4320
16	19	26.5	31.5	36	0	1380	3000	3710
20	19	25.6	31.5	36	0	780	2524	2904

Siphon Height, in.	Air Flow, Liters				Solution Consumption, ml/h			
	Air Pressure, psi				Air Pressure, psi			
4	34	69	103	138	34	69	103	138
8	19	26.5	31.5	36	2100	2760	3284	4256
12	19	26.5	31.5	36	636	2760	3720	4320
16	19	26.5	31.5	36	0	1380	3000	3710
20	19	25.6	31.5	36	0	780	2524	2904


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condition when operated at the air pressure selected. Nozzles are not necessarily located at one end, but may be placed in the center and can also be directed vertically up through a suitable tower.

X1.4 Air for Atomization

X1.4.1 The air used for atomization must be free of grease, oil, and dirt before use by passing through well-maintained filters. Room air may be compressed, heated, humidified, and washed in a water-sealed rotary pump if the temperature of the water is suitably controlled. Otherwise cleaned air may be introduced into the bottom of a tower filled with water through a porous stone or multiple nozzles. The level of the water must be maintained automatically to ensure adequate humidification. A chamber operated in accordance with this method and Appendix X1 will have a relative humidity between 95 and 98%. Since salt solutions from 2 to 6% will give the same results (though for uniformity the limits are set at 4 to 6%), it is preferable to saturate the air at temperatures well above the chamber temperature as insurance of a wet fog. Table X1.2 shows the temperatures, at different pressures, that are required to offset the cooling effect of expansion to atmospheric pressure.

TABLE X1.2 Temperature and Pressure Requirements for Operation of Test at 55°F

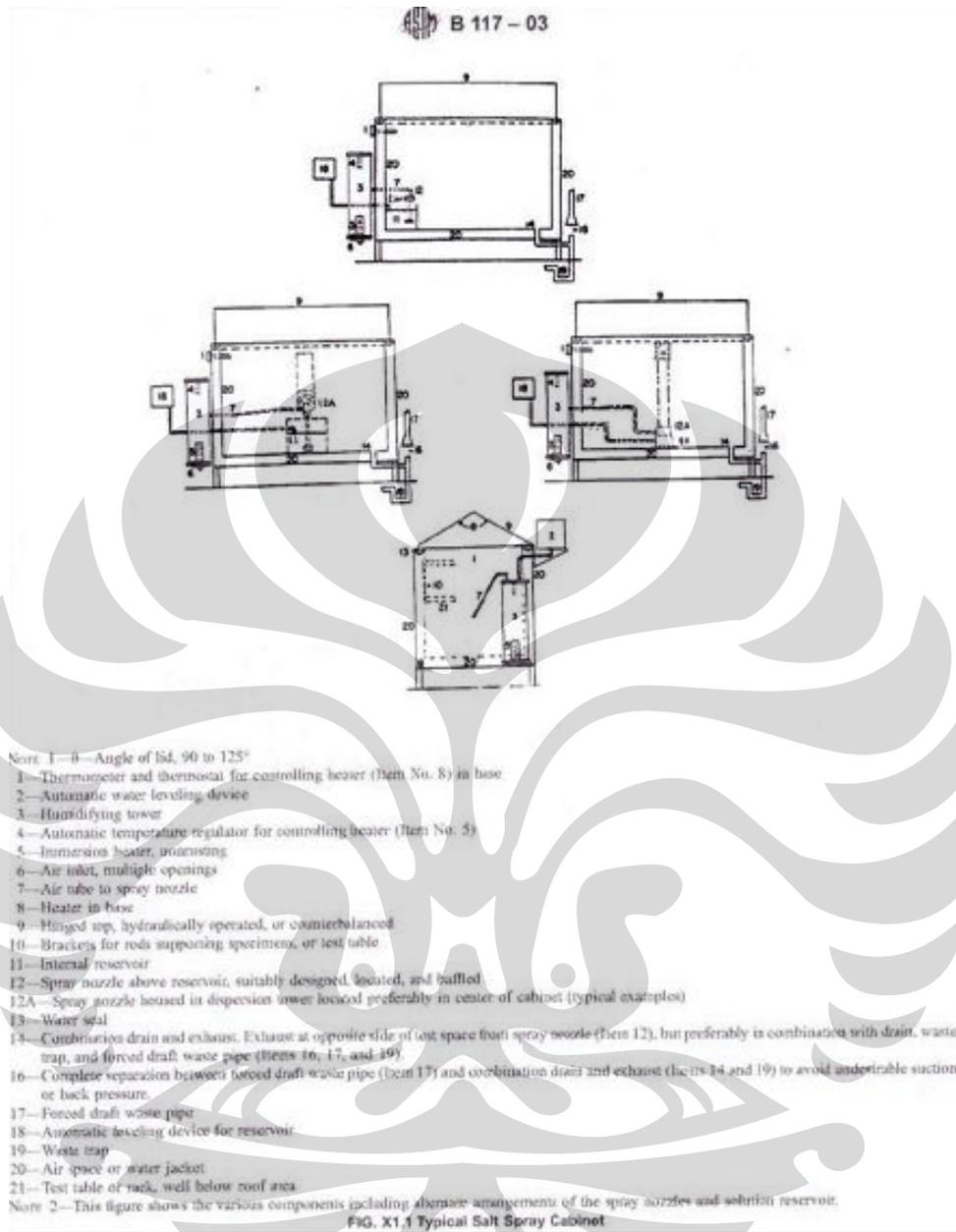
Temperature, °C	Air Pressure, kPa			
	80	96	110	124
Temperature, °F	Air Pressure, psi			
	172	14	16	18
	114	117	119	121

X1.4.2 Experience has shown that most uniform spray chamber atmospheres are obtained by increasing the atomizing air temperature sufficiently to offset heat losses, except those that can be replaced otherwise at very low-temperature gradients.

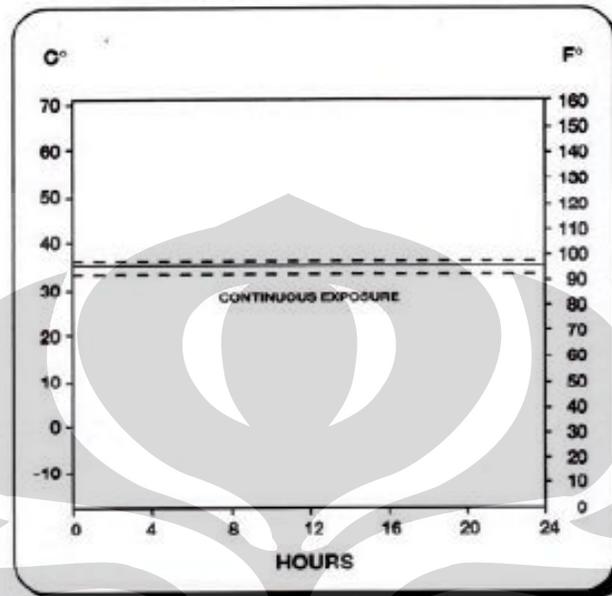
X1.5 Types of Construction

X1.5.1 A modern laboratory cabinet is shown in Fig. X1.1. Walk-in chambers are usually constructed with a sloping ceiling. Suitably located and directed spray nozzles avoid ceiling accumulation and drip. Nozzles may be located at the ceiling, or 0.91 m (3 ft) from the floor directed upward at 30 to 60° over a passageway. The number of nozzles depends on type and capacity and is related to the area of the test space. An 11 to 19 L (3 to 5-gal) reservoir is required within the chamber, with the level controlled. The major features of a walk-in type cabinet, which differs significantly from the laboratory type, are illustrated in Fig. X1.2. Construction of a plastic nozzle, such as is furnished by several suppliers, is shown in Fig. X1.3.





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- (1) Salt Solution: 5 ± 1 parts by mass of sodium chloride (NaCl) in 95 parts by mass of Specification D 1193 Type IV water.
 (2) pH 6.5 to 7.2 of collected solution.
 (3) The exposure zone of the salt spray chamber shall be maintained at $35 \pm 1.1^\circ\text{C}$ ($95 \pm 2^\circ\text{F}$). Each salt point and its tolerance represents an operational control point for exposure conditions at a single location in the cabinet which may not necessarily represent the uniformity of conditions throughout the cabinet.
 (4) Fog at a rate of 1.0 to 2.0 mL/hr per 60 cm² of horizontal collection area.

Note: Dashed chart lines indicate temperature tolerance limits.
 Note: Record with permission.

FIG. X2.1 Standard Practice for Operating Salt Spray (Fog) Apparatus

X3. EVALUATION OF CORROSIVE CONDITIONS

X3.1 General—This appendix covers test panels and procedures for evaluating the corrosive conditions within a salt spray cabinet. The procedure involves the exposure of steel test panels and the determination of their mass losses in a specified period of time. This may be done monthly or more frequently to ensure consistent operation over time. It is also useful for correlating the corrosive conditions among different cabinets.

X3.2 Test Panels—The required test panels, 76 by 127 by 0.8 mm (3.0 by 5.0 by .0315 in.), are made from SAE 1008 commercial-grade cold-rolled carbon steel (UNS G10080).

X3.3 Preparation of Panels Before Testing—Clean panels before testing by degreasing only, so that the surfaces are free of dirt, oil, or other foreign matter that could influence the test results. After cleaning, weigh each panel on an analytical balance to the nearest 1.0 mg and record the mass.

X3.4 Positioning of Test Panels—Place a minimum of two weighed panels in the cabinet, with the 127-mm (5.0 in.) length supported 90° from vertical. Place the panels in the proximity of the condensate collectors. (See Section 6.)

X3.5 Duration of Test—Expose panels to the salt fog for 48 to 168 h.

X3.6 Cleaning of Test Panels After Exposure—After removal of the panels from the cabinet, rinse each panel immediately with running tap water to remove salt, and rinse in reagent grade water (see Specification D 1193, Type IV). Chemically clean each panel for 10 min at 20 to 25°C in a fresh solution prepared as follows:

Mix 1000 mL of hydrochloric acid (36 to 38%) with 1000 mL reagent grade water (D 1193, Type IV) and add 50 g of hexamethylenetetramine. After cleaning, rinse each panel with reagent grade water (Type IV) and dry (see 13.2).

X3.7 Determining Mass Loss—Immediately after drying, determine the mass loss by reweighing and subtracting panel mass after exposure from its original mass.

TABLE X3.1 Repeatability Statistics

Note—Based on two replicates in every test run. No. = number of different salt spray cabinets in test program; r = 95 % repeatability limits, g; C_v = S_r/avg , coefficient of variation, % and S_r = repeatability standard deviations, g.

Materials	Test Duration, h	Average Mass Loss, g	S_r , g	C_v , %	r , g	No.
QP1	48	0.8170	0.5538	7.20	0.1845	12
QP1	96	1.5347	0.1048	7.38	0.2574	12
QP1	168	2.5996	0.2498	9.61	0.6994	12
AP	48	0.7787	0.0403	5.17	0.1128	10
AP	96	1.4094	0.0923	6.58	0.2584	10
AP	168	2.4395	0.1894	8.58	0.4483	10
QP2	48	0.8586	0.0985	8.01	0.1921	5
QP2	96	1.5720	0.0978	6.21	0.2733	5
QP2	168	2.7600	0.2588	9.38	0.7240	5

TABLE X3.2 Reproducibility Statistics

Note—No. = number of different salt spray cabinets in test program; R = 95 % reproducibility limits, g; C_v = S_R/avg , coefficient of variation, % and S_R = reproducibility standard deviations, g.

Materials	Test Duration, h	Average Mass Loss, g	S_R , g	C_v , %	R , g	No.
QP1	48	0.8170	0.0947	11.38	0.2752	12
QP1	96	1.5347	0.2019	14.02	0.3653	12
QP1	168	2.5996	0.3285	12.52	0.9114	12
AP	48	0.7787	0.0809	10.35	0.2394	10
AP	96	1.4094	0.1826	11.54	0.4557	10
AP	168	2.4395	0.3402	14.00	0.9525	10
QP2	48	0.8586	0.1820	18.88	0.3581	5
QP2	96	1.5720	0.1310	8.35	0.3093	5
QP2	168	2.7600	0.3873	14.03	1.0644	5

X3.7.1 Data generated in the interlaboratory study using this method are available from ASTM as a Research Report.³

³ Available from ASTM Headquarters. Report RR No. G1-9903.

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X3.8 Precision and Bias—Steel Panel Test:

X3.8.1 An interlaboratory test program using three different sets of UNS G10080 steel panels, 76 by 127 by 0.8 mm (3.0 by 5.0 by .0315 in.) has shown that the repeatability of the mass loss of the steel panels, that is, the consistency in mass loss results that may be expected when replicate panels are run simultaneously in a salt spray cabinet, is dependent upon exposure time and the panel lot or source. The interlaboratory program yielded repeatability standard deviations, S_r , from which 95 % repeatability limits, r , were calculated as follows (see Practice E 691):

$$r = 2.85 S_r \quad (X3.1)$$

The values of S_r and r are reported in Table X3.1. Note that the corrosion rate of steel in this environment is approximately constant over the exposure interval and that the ratio of the standard deviation to the average mass loss, the coefficient of variation, C_v , varies between 5 and 10 % with a weighted average of 7.4 % and an r of ± 21 % of the average mass loss.

X3.8.2 This interlaboratory program also produced results on the reproducibility of results, that is, the consistency of mass loss results in tests in different laboratories or in different cabinets in the same facility. This program yielded reproducibility standard deviations, S_R , from which 95 % reproducibility limits, R , were calculated as follows (See Practice E 691):

$$R = 2.85 S_R \quad (X3.2)$$

The values of S_R and R are reported in Table X3.2. Note that the ratio of standard deviation to the average mass loss, the coefficient of variation, C_v , varies between 8 to 18 % with a weighted average of 12.7 % and an R of ± 36 % of the average mass loss.

X3.8.3 The mass loss of steel in this salt spray practice is dependent upon the area of steel exposed, the temperature, time of exposure, salt solution make up and purity, pH, spray conditions, and the metallurgy of the steel. The procedure in Appendix X3 for measuring the corrosivity of neutral salt spray cabinets with steel panels has no bias because the value of corrosivity of the salt spray is defined only in terms of this practice.

Lampiran 5 – Evaluasi sampel *coating*

 Designation: D 1654 – 92 (Reapproved 2000)

Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments¹

This standard is issued under the fixed designation D 1654; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This test method covers the treatment of previously painted or coated specimens for accelerated and atmospheric exposure tests and their subsequent evaluation in respect to corrosion, blistering associated with corrosion, loss of adhesion at a scribe mark, or other film failure.

1.2 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

- B 117 Practice for Operating Salt Spray (Fog) Testing Apparatus²
- D 610 Test Method for Evaluating Degree of Rusting on Painted Steel Surfaces³
- D 714 Test Method for Evaluating Degree of Blistering of Paints⁴
- D 870 Practice for Testing Water Resistance of Coatings Using Water Immersion⁵
- D 1014 Practice for Conducting Exterior Exposure Tests of Paints on Steel⁶
- D 1735 Practice for Testing Water Resistance of Coatings Using Water Fog Apparatus⁶
- D 2247 Practice for Testing Water Resistance of Coatings in 100% Relative Humidity⁶
- D 2803 Guide for Filiform Corrosion Resistance of Organic Coatings on Metal⁶
- D 4141 Practice for Conducting Accelerated Outdoor Exposure Tests of Coatings⁴
- D 4585 Practice for Testing Water Resistance of Coatings Using Controlled Condensation⁴
- D 4587 Practice for Conducting Tests on Paint and Related

Coatings and Materials Using a Fluorescent UV-Condensation Light- and Water-Exposure Apparatus⁷

G 23 Practice for Operating Light-Exposure Apparatus (Carbon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials⁸

G 26 Practice for Operating Light-Exposure Apparatus (Xenon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials⁸

G 85 Practice for Modified Salt Spray (Fog) Testing⁶

G 87 Practice for Conducting Moist SO₂ Tests⁶

2.2 ANSI Standard:

B94.50 Single-Point Cutting Tools, Basic Nomenclature and Definitions for⁷

3. Significance and Use

3.1 This method provides a means of evaluating and comparing basic corrosion performance of the substrate, pretreatment, or coating system, or combination thereof, after exposure to corrosive environments.

4. Apparatus

4.1 *Scribing Tool*—A straight-shank tungsten carbide tip, lathe cutting tool (ANSI B94.50, Style E) or carbide-tipped pencil-type tool is recommended. Any other type of scribing instrument such as a scalpel, razor blade, knife, or other sharp pointed tool is unacceptable unless agreed upon between the producer and the user.

4.2 *Straightedge*—Any straightedge of sufficient length and rigidity to guide the scribing tool in a straight line.

4.3 *Air Source*—A source of compressed air capable of delivering at least 10 ft³/min (4.72 L/s) at 80 psi (552 kPa).

4.4 *Air Gun*—An air dusting gun and nozzle combination⁸ to meet the following specification:

Air Consumption, ft ³ /min (m ³ /min)	Pressure, psi (kPa)	Nozzle Diameter, in. (mm)
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¹ This method is under the jurisdiction of ASTM Committee D01 on Paint and Related Coatings, Materials, and Applications and is the direct responsibility of Subcommittee D01.25 on Evaluation of Weathering Effects.

Current edition approved Oct. 15, 1992. Published December 1992. Originally published as D 1654 – 59. Last previous edition D 1654 – 79a (1984).²

³ Annual Book of ASTM Standards, Vol. 03.02.

⁴ Annual Book of ASTM Standards, Vol. 06.02.

⁵ Annual Book of ASTM Standards, Vol. 06.01.

⁶ Discontinued; G 23 replaced by G 152 and G 153; G 26 replaced by G 155. See 2000 Annual Book of ASTM Standards, Vol. 14.04.

⁷ Annual Book of ASTM Standards, Vol. 03.02.

⁸ Available from American National Standards Institute, 11th Floor, 11 W. 42nd St., New York, NY 10018.

⁹ Spray gun and nozzles, Model No. AA23ETP0020 have been found satisfactory and may be obtained from Spray Systems Co., North Avenue at Schmale Road, Wheaton, IL 60187. Equivalents may be used.

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8.4 (0.24) 80 (500) 6.12 (3.0)

4.4.1 A guard consisting of barriers, baffles, or screens is required to protect the operator and other individuals near the area where the air is being used. The guard must be placed between the air nozzle and the operator. A device such as a sand-blasting cabinet has been found to be acceptable.

Note 1.—The use of an air gun without a guard is in violation of the U. S. Occupational Safety and Health Administration regulation.

4.5 *Scraping Tool*—A rigid spatula, knife, or similar instrument with no sharp edges or sharp corners.

4.6 *Scale*—Any rule with 1-mm divisions.

5. Preliminary Treatment of Test Specimens

5.1 Scribed Specimens:

5.1.1 Where specified or agreed upon, prepare each specimen for testing by scribing it in such a manner that the scribe can be exposed lengthwise when positioned in the test cabinet. This position will allow solution droplets to run lengthwise along the scribe.

5.1.2 Scribe the specimen by holding the tool at approximately a 45° angle to the surface. Position the tool so that only the carbide tip is in contact with the surface. Pull the scribing tool to obtain a uniform V-cut through the coating that is being tested. Inspect the tool frequently for dulling, chipping or wear and replace or repair as needed. The scribe should be of sufficient length to cover the significant test area, but should not contact the edge of the specimen. The scribe must penetrate all organic coating layers on the metal, leaving a uniformly bright line of burrs. The extent of scribe penetration through metallic coatings should be agreed upon between the producer and user. Quality of the scribe may be observed with the aid of low-power magnification. Note, mark, and describe defects, coding, and flaws that may affect results.

5.1.3 Scribe lines other than those of a single, straight nature may be used if agreed upon between the producer and the user.

5.1.4 Expose scribed specimens in accordance with 6.1 and rate in accordance with Section 7.

5.2 *Unscribed Specimens*—Specimens coated with paint, undercoats, oils, or waxes may be evaluated without a scribe. Expose such specimens in accordance with Section 6 and rate for corrosion of the general surface in accordance with Section 8.

5.3 *Cut Edges*—Cut edges of panels may be exposed during testing, or protected by wax, tape, or other means as agreed upon between the producer and the user. If left unprotected, method of shearing panel edges should be agreed upon between the producer and user, noting whether edges are oriented in the "burr up" or "burr down" configuration.

5.4 *Deformation*—Deformation of test panels prior to exposure, if desired, should be agreed upon between the producer and user.

6. Exposure of Test Specimens

6.1 Expose test specimens in accordance with one or more of the following test methods or practices: B 117, D 610, D 714, D 870, D 1014, D 1735, D 2247, D 2803, D 4141, D 4585, D 4587, G 23, G 26, G 85, G 87, or any other applicable test method, as agreed upon between the producer and

the user. The length of test and evaluation intervals should be agreed upon prior to exposure of specimens.

7. Procedure A—Evaluation of Scribed Specimens

7.1 *Method 1 (Air Blow-Off)*—Rinse each specimen after completion of the exposure period, using a gentle stream of water at a temperature up to 110°F (45°C). Holding the nozzle at approximately a 45° angle, blow along the entire scribe line, disturbing the surface adjacent to the scribe mechanically by the air nozzle to ensure an opening for the air blast. Complete the air blasting within 15 min of specimen removal from the exposure cabinet. If the air blasting cannot be completed within the prescribed time, immerse the specimens in water at room temperature or store in a plastic bag to avoid any drying effect.

7.2 *Method 2 (Scraping)*—Rinse the specimen after completion of the exposure period, using a gentle stream of water at a temperature up to 110°F (45°C). Scrape the specimen vigorously with an instrument described in 4.5 while under the gentle stream of the rinse water. Hold the scraper with its face perpendicular to the specimen surface and parallel to the scribe, moving it back and forth across the scribe to remove the coating that has been undercut and has suffered loss of adhesion only, not to remove the coating that still has adhesion. Complete the scraping within 15 min of specimen removal from the exposure cabinet. If scraping cannot be completed within the prescribed time, immerse the specimens in water at room temperature or store in a plastic bag to avoid any drying effect.

Note 2.—Rinsing, scraping, or air blow off may not be appropriate in all cases, such as for interim ratings in continuing tests. Alternative methods may be used if agreed upon between the producer and the user.

7.3 *Rating*—Rate the corrosion or loss of paint extending from a scribe mark as prescribed in Table 1. Record the representative mean, maximum, and minimum creepage from the scribe, and note whether or not the maximum is an isolated spot. Record creep values in millimeters, inches, or rating numbers, as agreed upon between producer and user.

7.3.1 Unless otherwise agreed upon by the producer and user, scribe creepage is defined as "one sided", that is, from the original scribe line to the creepage front. Also, rate in accordance with Table 2 the prevalence of corrosion on areas removed from the scribe.

8. Procedure B—Evaluation of Unscribed Areas

8.1 Rinse the specimen after completion of the exposure

TABLE 1 Rating of Failure at Scribe (Procedure A)

Representative Mean Creepage From Scribe		
Millimetres	Inches (Approximate)	Rating Number
Zero	0	10
Over 0 to 0.5	0 to 1/16	9
Over 0.5 to 1.0	1/16 to 1/8	8
Over 1.0 to 2.0	1/8 to 1/4	7
Over 2.0 to 3.0	1/4 to 3/8	6
Over 3.0 to 5.0	3/8 to 1/2	5
Over 5.0 to 7.5	1/2 to 3/4	4
Over 7.5 to 10.0	3/4 to 1	3
Over 10.0 to 13.0	1 to 1 1/8	2
Over 13.0 to 16.0	1 1/8 to 5/8	1
Over 16.0 to more	5/8 to more	0

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TABLE 2 Rating of Unscribed Areas (Procedure B)

Area Failed, %	Rating Number
No failure	10
0 to 1	9
2 to 3	8
4 to 6	7
7 to 10	6
11 to 20	5
21 to 30	4
31 to 40	3
41 to 55	2
56 to 75	1
Over 75	0

period (Section 6), using a gentle stream of water at a temperature up to 100°F (40°C). Dry the surface of the specimen with paper towels or compressed air. Drying should be done in such a manner that the corrosion on the specimen surface is not disturbed.

8.2 Evaluate unscribed specimens for corrosion spots, blisters, and any other types of failure that may occur. Where the character of the failure permits, the photographic blister standards given in Test Method D 714 may be used to describe the results of the exposure test, with respect to size of blisters or corroded areas, while Method D 610 may serve to describe the frequency and distribution of rusting. Record the size, frequency, or area affected. Discount corrosion within 1/16 in. (1.27 mm) of edges.

8.3 *Rating*—Record percent failed area or convert percent failure to rating numbers in accordance with Table 2 as agreed upon between the producer and user.

Note 3—Formation of under-film corrosion may be evaluated and reported in accordance with Table 2 if the film is first carefully stripped with a neutral stripper. Exercise care to avoid alteration of the corrosion pattern or pretreatment.

Note 4—Where the character of the failure permits, the photographic blister standards given in Test Method D 714 may be used to describe the

results of the exposure test, in respect to size of blisters or corroded areas, while Method D 610 may serve to describe the frequency and distribution, if desired.

9. Procedure C—Evaluation of Unprotected Edges

9.1 If paint creepage from cut edges is tested, rate the corrosion or loss of paint extending from a cut edge in the same manner described for scribes in Procedure A.

10. Procedure D—Evaluation of Formed Areas

10.1 If tested samples contain bends, dimples, or other formed areas of interest, rate the extent of failure at these areas separately in the same manner described in Procedure B, or as agreed upon between the producer and user.

11. Report

11.1 The report shall include the following information, unless otherwise agreed upon between the producer and user:

11.1.1 All pertinent information regarding the conduct of each corrosion test, as prescribed in the specifications for each test.

11.1.2 Methods of scribing, shearing, or forming, or combination thereof, or test specimens.

11.1.3 Ratings of test specimens, including procedure(s) employed.

12. Precision and Bias

12.1 *Precision*—Since this is a method of evaluation based on measurements after various tests, the statement of precision applicable to each specific method of exposure to corrosive environments applies.

13. Keywords

13.1 blistering; corrosion; paints/related coatings/materials; creepage; edge/scribe; rust

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