

# **THE** **MARINE PAINTING FORUM**

**IT WAS ESTABLISHED IN 1988 & HELD ITS  
INAUGRAL MEETING IN APRIL OF THAT  
YEAR**

The forum was established to enable companies involved in the construction and preservation of ships to discuss technical, practical, legislative & regulatory matters of mutual interest. Membership is open to Shipowners and Operators, Shipbuilders and Shiprepairers, Painting Contractors, Paint Manufacturers, Raw Material Suppliers to the Paint Industry, Abrasive Suppliers and Manufacturers.

Projects relating to the Marine Paint Industry are conceived from within the FORUM, and funds are provided for project work from annual subscriptions paid by member Companies.

One such Project has been an investigation into:

**“WATER SOLUBLE  
CONTAMINATION FROM  
GRITBLASTING ABRASIVES”**

**TWENTY-ONE SAMPLES OF EXPENDABLE  
ABRASIVE WERE COLLECTED FROM EIGHT  
COUNTRIES**

**DEMMARK**

**GERMANY**

**SPAIN**

**GREECE**

**UNITED KINGDOM**

**NORWAY**

**AUSTRALIA**

**SINGAPORE**



**ABRASIVES WERE OF THE FOLLOWING  
TYPES:**

**QUARTZ SAND**

**ALUMINIUM SILICATE**

**COPPER SLAG**

**OLIVINE SAND**

**GARNET**

**NICKEL SLAG**

**MINERAL SLAG**  
(UNSPECIFIED TYPE)

# **ASSESSMENT**

**SOLUBLE SALTS WERE EXTRACTED  
WITH  
AnalaR DE-IONISED WATER  
AND ANALYSED FOR:**

## **CONDUCTIVITY**

**mille-Siemens/metre (mS/m)**

## **TOTAL DISSOLVED SALTS**

**milligrams/Kilogram (mg/Kg)**

## **SULPHATE CONTENT**

**milligrams/Kilogram (mg/Kg)**

## **CHLORIDE CONTENT**

**milligrams/Kilogram (mg/Kg)**



## ANALYSIS OF WATER EXTRACT

(u) = Unknown

Source	Type	Conduc- -tivity mS/m	TDS m/Kg	SO <sub>4</sub> <sup>++</sup> m/Kg	Cl <sup>-</sup> m/Kg
DENMARK	Quartz Sand	1.51	18.0	8.0	1.5
DENMARK	Al Silicate	2.65	38.0	10.6	2.0
GERMANY	Cu Slag	8.87	109.0	30.5	9.0
UK	Cu Slag	5.50	62.0	15.1	3.5
SPAIN	Cu Slag	8.06	82.0	27.4	4.0
GREECE	Cu Slag	7.79	158.0	23.8	57.0
GREECE	Cu Slag	6.20	85.0	20.6	21.5
SINGAPORE	Cu Slag	6.07	64.0	4.8	17.0
AUSTRALIA	Garnet	5.17	112.0	14.2	30.5
UK	Cu Slag	3.19	60.0	8.2	1.0
AUSTRALIA	Garnet	6.26	97.0	3.4	22.0
NORWAY	Olivine Sand	4.39	71.0	3.7	1.0
GREECE	Slag (u)	84.00	532.0	47.6	258.0
GREECE	Slag (u)	7.24	127.0	12.3	55.5
GREECE	Slag (u)	6.50	78.0	4.6	23.0
GREECE	Slag (u)	8.75	130.0	13.7	46.5
GREECE	Slag (u)	8.28	169.0	17.8	71.5
GREECE	Slag (u)	55.00	810.0	91.9	358.0
NORWAY	Olivine	4.80	113.0	19.2	40.5
SPAIN	Slag (u)	25.00	138.0	21.5	26.0
SPAIN	Slag (u)	31.00	191.0	26.6	30.5

### Acknowledgements

I am indebted to a number of people and organisations for their contributions to this project.

First of all to the members of the **"Abrasives Sub-Committee"** for the time they have spent in making their contributions to various aspects of the project, both at Committee meetings, and during their own time.

I am also grateful to the members of the **Marine Painting Forum**, particularly the Chairman - Mr D M Allison RCNC, for their informed input. The **Grit Suppliers and Painting Contractors** within the Forum must also be praised for their contributions of significant quantities of various abrasives used throughout the project, and their undoubted expertise.

I am grateful to Mr Trevor Parry of Scientific and Technical Services Ltd for two reasons. Firstly for acting as a 'sounding board' for various technical aspects of this work, and secondly for ensuring that costs were kept within budget.

Finally, special mention must be given to Mr Derrick Bailey - Secretary to the Marine Painting Forum, for his timely and accurate recording of minutes.

W WOODS

Sub-Committee Chairman

Abrasives Project



## Foreword

The **Marine Painting Forum** was established in 1988, and held its inaugural meeting in April of that year.

The Forum is composed of representatives of companies covering a broad cross section of industries, all of whom have one thing in common - Painting Ships. The painting of ships involves many skills and disciplines, which are provided by a diverse cross section of companies within the Forum. Such companies are:

SHIP OWNERS and OPERATORS  
SHIPBUILDERS and SHIPREPAIRERS  
PAINTING CONTRACTORS  
PAINT MANUFACTURERS  
RAW MATERIAL SUPPLIERS (Paint Industry)  
ABRASIVE SUPPLIERS and MANUFACTURERS

The Forum was established to enable companies involved in the construction and preservation of ships to discuss technical, practical, legislative and regulatory matters of mutual interest.

Projects relating to the Marine Paint Industry are conceived from within the Forum, and funds are provided for project work from annual subscriptions paid by member Companies. Projects are monitored and controlled by various sub-committees each chaired by a sub-committee chairman. Regular reports are presented by sub-committee Chairman both verbally at Forum meetings and in written form periodically. Projects are discussed in some detail at meetings to ensure input from the complete cross-section of the Forum. Any reports produced for publication are attributed to the Marine Painting Forum.

## Preface

Abrasives have been used commercially in the Marine paint industry in abrasive blasting processes for the past forty years. In conjunction with high velocity dry air they provide a very effective means of removing corrosion, coatings, and contamination from steel surfaces.

The resultant abrasive blasted surface is significantly cleaner, and has the added benefit of an etched or roughened surface, which improves adhesion of surface coatings.

The extent to which the surface is cleaned is dependant on a number of factors including:

- The initial condition of the surface
- The effectiveness of the abrasive blasting process
- The nature, shape, and size of the abrasive

The cleanliness of abrasive blasted surfaces for many years has been assessed primarily by its appearance to the naked eye. In recent years more attention has been focussed on the 'Chemical cleanliness' of the surface ie. the presence or absence of salts invisible to the naked eye, which can markedly affect the performance of paint systems applied to the surface.

In more recent years, it has been recognised that abrasives contaminated with salts may actually contribute to contamination levels remaining on the steel, prior to application of paints. Recognising this, a project was proposed to investigate Contamination (Salts) arising from gritblasting abrasives. Initially three objectives were set:

- (i) Establish the levels of water soluble salts present on the surface of expendable abrasives, currently used in industry.

(iii)



- (ii) Examine the transfer of soluble salts from the abrasives to the abrasive blasted surface.
- (iii) Examine the effects of known levels of soluble salts on the performance of a paint system.

Since commencing the work in early 1992 a number of phases have been completed. The work methods, arising observations and conclusions are reported in the following text.

## WATER SOLUBLE CONTAMINATION FROM GRITBLASTING ABRASIVES

### Table of Contents

	<u>Page</u>
1. Assessment of Proprietary Expendable Abrasives	1
2. Investigation of Transfer of Salts from Abrasives to Steel Surfaces	5
3. Investigation of Effect of Salt Contamination on Performance of Paint Systems applied to Steel Surfaces	9
4. Further Work arising from Previous Work in Sections 1, 2 , and 3	12
5. Project Conclusions	19



## Water Soluble Contamination from Gritblasting Abrasives

### 1. Assessment of Proprietary Abrasives

#### 1.1 Introduction

It was considered to be an important first step in this project to identify what levels of contamination existed on proprietary materials already being used in the market place. Samples were supplied for examination from the following countries:

Denmark  
Germany  
Spain  
Greece  
United Kingdom  
Norway  
Australia  
Singapore

All abrasives assessed were expendable types and consisted of the following types:

Quartz Sand	(1)
Aluminium Silicate	(1)
Copper Slag	(7)
Olivine Sand	(2)
Garnet	(2)
Nickel Slag	(1)
Mineral Slag (unspecified)	<u>(7)</u>
	<u>21</u>

In total 21 samples of abrasive were collected from 8 countries. In some cases specifications were supplied with the abrasive samples. In all cases the samples were alleged to be unused virgin materials, although it was visibly clear that some samples of abrasive did contain other materials, such as bits of wood and fibres, and some doubt must be expressed concerning their previous history.

## 1.2 Assessment Method

All samples of abrasive were extracted with 'AnalaR' de-ionised water, and extract was analysed for the following:

- (i) Conductivity – milli-Siemens/metre (mS/m)
- (ii) Total Dissolved Solids – milligrams/Kilogram (mg/Kg)
- (iii) Sulphate Content – milligrams/Kilogram (mg/Kg)
- (iv) Chloride Content – milligrams/Kilogram (mg/Kg)

The results of these investigations are detailed in  
Table 1. Blast Cleaning Abrasives – Analysis of Water Extract  
Table 2. Comparison of Analyses

## 1.3 Observations from Analyses

1. Abrasive exhibiting lowest conductivity reading on extract was Quartz Sand from Denmark – Sample No. 1
2. Highest conductivity level was obtained from Sample No. 13 – Slag from Greece.
3. Highest Chloride level was obtained from Sample No. 18 – Slag from Greece, which also exhibited the highest Total Dissolved Solids, but not the highest conductivity.
4. Lowest Chloride level was obtained from Samples Nos. 10 and 12, Copper Slag and Olivine Sand respectively. However, neither of these exhibited the lowest Total Dissolved Solids, or the lowest conductivity.
5. The two samples of Olivine Sand – Samples 12 and 19 exhibited very different chloride levels, different Total Dissolved Solids, but similar conductivity levels.
6. The two samples of Garnet exhibited similar results for conductivity, and Total Dissolved Solids, but significant differences in Sulphate and Chloride content.



#### 1.4 Conclusions

1. Conductivity measurement is probably the most practical indicator of contamination.
2. A large proportion of the abrasives assessed from Greece and Spain would have failed to meet the current requirements for abrasives identified in recently established ISO and National Standards. Many contained Chloride in excess of the 25mg/Kg limit, and/or Conductivity levels (of aqueous extract) above 25mS/m.

## 2. Investigation of Transfer of Salts from Abrasives to Steel Surfaces

### 2.1 Introduction

The objective of this phase of the project was to measure the amount of salt transferred from abrasives with known contamination levels, to the steel surface. It was decided to limit the scope of this work by focussing only on 3 abrasives:

Copper Slag  
Olivine Sand  
Garnet

To eradicate any possible influences from the steel surface, decontaminated cold rolled steel was used, in these tests.

### 2.2 Assessment Method

#### 2.2.1 Contamination of Abrasives

1. Abrasives were washed with de-ionised 'AnalaR' water to zero contamination.
2. A predetermined volume of sodium chloride solution of known concentration was added to a weighed amount of the abrasives, and then thoroughly mixed. The abrasive was then dried in a warm controlled clean environment.
3. Each of the 3 abrasives was 'contaminated' with Sodium Chloride Solution, designed to give levels of 0, 50, 100, 200, and 400 ppm of chloride.
4. A further series of contaminated abrasives were produced at levels of 10, 20, 25, 30, 40 and 50 ppm chloride. Only one abrasive was contaminated at these levels (Copper Slag).
5. All dried contaminated abrasives were accurately checked for chloride content before commencing any abrasive blasting.

### 2.2.2 Abrasive Blast Cleaning

After thorough cleaning of C.R.C.A. panels using xylene followed by methyl alcohol, the panels were abrasive blasted in a non-recirculating enclosed blasting cabinet. The blast cleaning was carried out using constant pressure and nozzle size, and each panel was blast cleaned for the same time. The spent abrasive was collected and weighed for each grit at each contamination level, and the cabinet and lines were cleaned between each abrasive sample.

For each abrasive, six panels were grit blasted clean to Sa3 standard. At the completion of blast cleaning, each of the six panels were individually placed in a resealable polythene bag containing a sachet of silica gel to prevent rusting.

### 2.2.3 Analysis

Three panels of the six from each contamination level for each abrasive were taken for laboratory analysis, for conductivity and chloride levels.

The panels were washed with hot 'AnalaR' water at approximately 60°C, and the washings collected and filtered, then made up to a known volume with further 'AnalaR' water. The resultant solution was then tested for conductivity using a calibrated conductivity meter, and then a sample was taken and tested for chloride level. This test was carried out in accordance with ASTM D512-80 "Standard Test Methods for Chloride ion level in water"

Results are tabulated in Tables 3, 4, and 5.



#### 2.2.4 Observations from Transfer Tests

1. For all abrasive types, the amount of Chloride transferred increased as the chloride contamination level on the abrasive increased.

For both Copper slag and Olivine, graphical representation illustrates quite a good linear relationship. The same linear relationship could not be seen for Garnet, but all abrasives indicated a positive intercept on the 'y' axis, implying that a small amount of chloride contamination is inherent to all abrasives. See Graph I.

2. Of the amount of chloride projected at each panel on each abrasive, only a small percentage of chloride was actually transferred to the panels.

Transfer from Copper Slag varied between .37 to 0.58%

Transfer from Garnet varied between .41 to .7%

Transfer from Olivine varied between .21 to .25%

3. Surface conductivity readings plotted against Grit Contamination levels illustrates a reasonably linear relationship for Copper Slag and Olivine, but not such a linear relationship in respect of Garnet. However, for all abrasives a positive intercept on the 'y'-axis indicates that soluble salts, other than the chloride placed on the surface of the abrasive, have been transferred to the steel. The positive 'y' intercept for Garnet being higher than that for Olivine, which itself was higher than Copper Slag.

See Graph II

It may be significant that both Olivine and Garnet are naturally occurring abrasives, and therefore breaking down of the particles during the blasting process, may expose virgin surfaces, which may be contaminated themselves.

4. Olivine consistently transferred less of the available chloride, compared to both Garnet and Copper Slag.

This may be explained by the fact that Olivine breaks down readily on impact to produce more dust particles. These smaller dust particles are swept across the surface in the airstream, and may afford some secondary cleaning action by either adsorbing, or removing, recently deposited salt particles. This may account for the apparent lower chloride transfer of Olivine compared to a more durable abrasive such as Garnet, which would not breakdown so readily, and would not form as many dust particles.

There may be another explanation why the Copper Slag behaved differently to the Olivine. The grade of Copper Slag used would be expected to give a deeper profile compared to that from the Olivine because of larger particle size of the Copper Slag. This deeper profile obviously produces a greater actual surface area over the same apparent area, and therefore more area over which contamination can be deposited. Furthermore this deeper profile would not be so readily cleaned by the secondary cleaning action of small dust particles moving across the surface, in the airstream.

5. Garnet and Copper Slag transferred similar levels of chloride contamination to the steel surface. However, conductivity readings from washings of those surfaces were always higher on Garnet blasted panels. This suggests that for garnet a higher level of soluble salts are transferred to the steel on impact. Since the abrasives were washed in deionised water prior to "chloride-doping" the inference is that soluble salts are liberated from within the abrasive particles and transferred to the surface upon impact.



### 3. Investigation of the Effect of Salt Contamination on the Performance of Paint Systems on Steel Surfaces

- 3.1 It was considered necessary to try and establish a relationship between contamination levels on steel and performance of coating applied on to the steel. The remaining CRCA panels blast cleaned with each contaminated abrasive (see 2.2.2) were used for this assessment.

All panels were carefully coated with a 3 coat 'industry standard' epoxy/polyamide paint. The formulation for the 'industry standard' paint was kindly provided by Shell Chemicals U.K. Ltd.

The paint system consisted of 3 coats of paint applied in 3 spray coats to give a final total dry film thickness of 100 microns. 3 coats of paint were applied to try and ensure a uniform final dry film thickness of 100 microns.

The backs and edges of panels were protected with coal tar epoxy coating prior to water immersion.

#### 3.2 Water Immersion

After a curing period of 7 days at 20°C the painted panels were half immersed in de-ionised water at 25°C for a period of 14 weeks. Panels were assessed frequently particularly during the early part of testing and were assessed for blistering in accordance with ASTM D714. Both immersion and vapour phase areas were assessed. These results are tabulated in Tables 6, 7, 8, & 9.



### 3.3 Observations from Immersion Tests

- 3.3.1 Comparing failure times (denoted by appearance of initial blistering) to contamination levels, it is clear that an increase in levels of contamination on abrasive, resulted in an increase in contamination deposited on panels, which in turn resulted in shorter failure times.

In fact at high levels of abrasive chloride contamination of 325 – 390 ppm chloride, failure times were remarkably short ranging from 27 hours to 31 hours for all abrasives.

- 3.3.2 As abrasive Chloride contamination decreased towards 50 ppm time to failure generally increased.

<u>Abrasive</u>	<u>Failure Time in hours at High/Low</u>	
	<u>Contamination Levels</u>	
Copper Slag	325 ppm 31 hours	55 ppm 144 hours
Olivine Sand	360 ppm 31 hours	49 ppm 144 hours
Garnet	390 ppm 27 hours	50 ppm 72 hours

- 3.3.3 As can be seen the time to breakdown even at 50 ppm contamination levels was still only a matter of a few days. Six days in respect of Copper Slag and Olivine, and 3 in respect of Garnet.

Even at lower abrasive contamination levels (nominally zero) the failure times were still remarkably short.

Copper Slag – 16 days  
Olivine – 14 days  
Garnet – 6 days

3.3.3 This suggests 3 possibilities.  
(cont)

- (i) The test conditions were far too severe as a sorting test.
- (ii) The coating may have been too thin for the test conditions.
- (iii) Other contaminants may have been present on the steel surface. Surface conductivity measurements at an abrasive contamination level of 50 ppm gave the following results;

Copper Slag (42ppm) - 1.30 mS/m  
Olivine Sand (49ppm) - 1.76 mS/m  
Garnet (50ppm) - 2.22 mS/m

Recognising the short failure times for all abrasives at nominal zero contamination levels, it seems likely that the test conditions may have been too severe. However it may be significant that panels blasted with contaminated Garnet at all levels of contamination failed first at each of those levels;

Failure times for Olivine were generally between Garnet and Copper Slag. Copper Slag appearing to be the best.

Much more work is necessary in this area to substantiate these indications.

#### 4. Further Work arising from Previous Work in Sections 1, 2 and 3

Recognising the observations and indications from previous work reported earlier, it was felt necessary to do more work to investigate:

1. Relationship between blasting time, and degree of transfer of contamination from abrasives.
2. Intrinsic soluble matter held within, and/or on, abrasive particles.

##### 4.1 Effect of Gritblasting time on the Transfer of Contamination from Abrasives to a Steel Surface

Three abrasives were chosen for this work:

Copper Slag  
Olivine Sand  
Garnet

##### 4.1.1 Method

The abrasives were all washed with de-ionised water to remove surface contaminants. They were all then individually contaminated with known volumes of Sodium Chloride solution in de-ionised water of known concentration, dried and thoroughly mixed to produce four levels of contamination with chloride,

zero contamination  
25 ppm Chloride contamination  
50 ppm Chloride contamination  
75 ppm Chloride contamination

Actual Chloride levels are reported later in Section 4.1.2.



Each abrasive was then used to blast clean CRCA steel panels of known size to a visual standard corresponding to Swedish Standard Sa3.

Abrasive blasting was carried out in a non-recirculating blast chamber. After each blasting operation, spent abrasive was collected and weighed. The blast chamber and system being thoroughly cleaned between each operation.

A 'standard blasting time' was established for each abrasive. This being the time taken to abrasive blast the standard steel panels to Swedish Standard Sa3. Triplicate panels were abrasive blasted for each abrasive type, at four abrasive contamination levels, at standard time, 2 x standard time, and 3 x standard time.

All contaminated abrasives were analysed after contamination, (prior to use) to establish chloride contamination level, and all steel panels after gritblasting were assessed for Chloride contamination level, and surface conductivity.

#### 4.1.2 Results

Results are tabulated in TABLE 10.

#### 4.1.3 Observations from Results

1. As in previous transfer tests, the amount of chloride transferred increased as the degree of contamination on each abrasive increased.
2. There was little if any increase in deposited chloride as blasting duration increased from standard blasting time to treble blasting time. Contamination appears to reach equilibrium, where no further transfer appears to take place. Equilibrium was achieved at each abrasive contamination level, albeit at different levels.

3. In this series of tests Garnet transferred less of the available chloride contamination compared to both Copper Slag and Olivine Sand. Surface conductivity readings were always marginally lower than Copper Slag and significantly lower than Olivine Sand.
4. Olivine Sand always gave significantly higher surface conductivity readings than both Copper Slag and Garnet.

It was also noted that even at similar surface chloride contamination levels, Olivine Sand gave significantly higher surface conductivity readings compared to Copper Slag.

5. Abrasive contamination level appears to have more influence on contamination transfer than blasting time. eg.

If we consider Copper Slag contaminated with 23mg/kg of chloride.

At 3 x standard blasting time 3680 mgms of chloride was projected at the steel surface resulting in actual transfer of 8.9 mg/m<sup>2</sup>.

However at an abrasive contamination level of 75 mg/kg and standard blasting duration, 3700 mgms of chloride was projected at the surface, resulting in actual transfer of 16.6 mg/m<sup>2</sup>.

This trend was consistent for each abrasive.

#### 4.2 Investigation of Intrinsic Water Soluble Matter held within, and/or on Abrasives

##### Introduction

The original objectives of this part of the project was to compare the amount of water soluble matter available both on the surface , and from the interior of abrasive particles.



The effect of extraction with both hot and cold de-ionised water was also investigated.

In this investigation, the following abrasives were assessed:

- Copper Slag
- Olivine Sand
- Australian Garnet (i)
- Australian Garnet (ii)
- Indian Garnet (i)
- Indian Garnet (ii)
- American Garnet

Australian Garnets (i) and (ii) were two samples from the same supplier of the same grade of abrasive.

Indian Garnets (i) and (ii) were both of Indian origin, but of different colour and particle size, and from different suppliers.

The American Garnet was assessed as this was a 'mined' variety compared to those collected from sea beds in Australia and India.

#### 4.2.1 Method

A sample of each abrasive was divided into four smaller samples. Two samples were extracted with de-ionised water (one with cold de-ionised water, and the other with hot de-ionised water). The extract was then assessed for total conductivity and chloride content in accordance with ISO Standards.

The remaining samples were mixed together and crushed in an electrically powered crushing mill. That composite sample was also extracted, and the extract similarly assessed for conductivity and chloride.

#### 4.2.2 Results

These are tabulated in TABLE 11

#### 4.2.3 Observations from Results

1. For each abrasive, crushing significantly increases water extractable matter, resulting in an increase in conductivity.
2. Conductivity was also higher for both crushed and uncrushed abrasives when extracted with hot de-ionised water, compared to cold.
3. With the exception of Indian Garnet (ii), all abrasives complied with the recently established National and International standards, which permit levels of up to 25ppm chloride and 25 mS/m conductivity. Under these standards the specified methods of determination are performed on uncrushed abrasives. However, when the crushed abrasives were extracted, Olivine Sand gave results very close to the conductivity limit using cold de-ionised water, and exceeded the limit when extracted with hot de-ionised water.
4. None of the abrasives except Indian Garnet (ii) exceeded the limit for chloride content in any of the assessments. Increases in chloride occurred after crushing, and also with hot extraction in the case of Copper Slag and Olivine Sand.
5. Of the Garnet samples, the Indian Garnet (ii) clearly had very high levels of chloride, and gave very high conductivity readings. The Indian Garnet (i) appeared very similar to the Australian Garnet samples (i) and (ii), and all were well within specifications in current standards.

The American Garnet gave very low levels of Chloride, and the lowest conductivity for all the garnets.



Clearly, Garnets from different locations and origins have different characteristics, and need to be viewed as individual abrasives, rather than a classification of abrasive.

#### 4.3 Investigation into the Effect of Crushing on Water Soluble Extractables from Abrasives

##### Introduction

Recognising the results from Section 4.2, the investigation was extended to assess the effect of crushing on the amount of water soluble material extracted from abrasives. Three abrasives were assessed in this investigation:

Copper Slag  
Olivine Sand  
Garnet (Australian)

##### 4.3.1 Method

The three abrasives were crushed under standard conditions to varying degrees, using an electrically powered crushing mill. The crushed materials were examined for particle size distribution and extracted with cold de-ionised water. The water was then assessed for total conductivity, chloride content and sulphate content in accordance with ISO Standards.

The crushing time was standardised for all abrasives and varied to obtain the following:

1. Uncrushed virgin abrasive
2. Lightly crushed abrasive
3. Moderately crushed abrasive
4. Well crushed abrasive

##### 4.3.2 Results

The results of sieve analysis and the mean value of triplicate analytical determinations are detailed in TABLE 12.



#### 4.3.3 Observations from Results

1. All virgin abrasives gave conductivity and chloride results, well within levels recently established in International and National standards.  
(Less than 25 mS/m and 25 ppm respectively).
2. As the degree of crushing increased, the conductivity of aqueous extract also increased. In the case of the Copper Slag and Garnet both remained below 25 mS/m. In the case of Olivine Sand, conductivity rose from 15 mS/m to 25 mS/m for moderately ground material, to 27 mS/m for well ground material. This rise in conductivity being accompanied by a rise in chloride detected from 2.8 ppm to 5.7 ppm, and increase in sulphate detected from 25 ppm to 46 ppm.
3. Chloride content figures increased for both Copper Slag and Olivine Sand. No such increase was noted with Garnet, chloride content remaining almost constant.
4. Sulphate content figures increased for all three abrasives, as degree of crushing increased.

As can be seen from the results, significant increases in total conductivity of aqueous extract occurred as crushing increased. This obviously raises doubts concerning the most appropriate test method. Is it sensible to assess virgin unused abrasive, when further salts are made available during use of the abrasive, as it disintegrates?

It may be more realistic to modify current test methods to include a standard crushing procedure, before extraction of crushed abrasive with de-ionised water.

## 5. Project Conclusions

In common with many other pieces of scientific investigation, the project perhaps raised more questions than it actually resolved. However, some interesting observations have been made, and some conclusions have been reached.

5.1 Of the twenty one Proprietary Abrasive samples assessed in the first part of the project (Section 1), ten samples had chloride content above the newly established limit of 25 ppm. The new ISO and British Standards will result in an improvement of quality in respect of abrasive surface chloride contamination!

5.2 Conductivity measurement of aqueous extract of abrasive is probably the most practical method of assessing contamination on abrasives. (See 5.6 later)

5.3 Transfer of contamination from all abrasives increases as the concentration of contamination on the abrasive increases, and transfer appears to be linear in relation to concentration.

All abrasives indicated a positive intercept on the 'y' axis when transfer is plotted against grit contamination, indicating intrinsic contamination is available from the 'clean' abrasive.

(N.B. Clean abrasive is abrasive washed in de-ionised water to remove surface contamination.)

5.4 Transfer of salts from all three abrasives to steel, reaches an equilibrium level for all levels of abrasive contamination. This equilibrium level is higher as abrasive contamination levels increase.

5.5 Increase in the level of transferred salts reflects in a consequent decrease in water resistance of paint systems applied on top of salts.

In this project, no 'safe' levels of steel surface contamination could be established.



- 5.6 All abrasives assessed in Section 4.2 have soluble salts held within individual particles. As these particles are broken down to smaller particles more material becomes available for transfer to steel surfaces. In the case of one abrasive (Olivine Sand), the conductivity of aqueous extract of the crushed/used abrasive increased from an acceptable level, to an unacceptable level as the degree of crushing increased.

If this degree of particle disintegration occurs during normal use, then both intrinsic and superficial soluble matter may be transferred to the surface being treated.

This raises the question whether the analyses should be performed on crushed abrasive. If this was the case, and the limits were maintained at their present level, the Olivine abrasive would fail. However the results from the Transfer Tests in Section 2 demonstrated that Olivine consistently transferred less chloride from its surface than either Garnet or Copper Slag - See Section 2.2.4 'Observations From Transfer Tests'.

It should be noted however that the crushing process adopted in this assessment may have produced far greater disintegration of grit particles than that which occurs during normal gritblasting, and therefore salt liberation may not be so high in practice.

Furthermore, the amount of salt transfer at such low concentrations may have no significant effect on final paint performance.

The work carried out in this project has produced some interesting observations and conclusions and raised a number of new questions. The influence of particle size and hardness of abrasive, on transfer of contamination from abrasive to surface, merits closer investigation.

This project has focussed on expendable abrasives, which are shown to liberate intrinsic salts during use. The abrasives are also likely to suffer further contamination from corroded and painted steel surfaces themselves. End users should not be tempted to re-use expendable abrasives as clearly the salt content and the conductivity of aqueous extract are both likely to increase once they are used.

'Used' abrasive may however, be re-used if it is subjected to a suitable re-cycling process. Alternatively, unre-cycled used abrasive may be acceptable on other surfaces e.g. non-metallic surfaces, or on metallic surfaces subjected to less demanding environments.

It is clear that results from some of the work in this project were misleading due to the intrinsic contamination held within abrasive particles. In any future work, more complete characterisation of each abrasive in respect of the nature and degree of intrinsic contamination, and particle size distribution is recommended, before proceeding to assessments of a more practical nature. Sufficiently large samples of each abrasive of known particle size distribution must also be available at the beginning of the project to eliminate the need for further deliveries of abrasive, which may be different in some respects to that previously used. 'Batch to Batch' variation should be eliminated by using only one batch of each abrasive.

W WOODS

CHAIRMAN - ABRASIVE PROJECT SUB-COMMITTEE



# BLAST CLEANING ABRASIVES – ANALYSIS OF WATER EXTRACT

No.	Source	Type	Conductivity mS/m	T.D.S mg/kg	Sulphate mg/kg	Chloride mg/kg
1	Denmark	Quartz Sand	1.51	18.0	8.2	1.5
2	Denmark	Alum. Silicate	2.65	38.0	10.6	2.0
3	Germany	Copper Slag	8.87	109.0	30.5	9.0
4	U.K.	Copper Slag	5.50	62.0	15.1	3.5
5	Spain	Copper Slag	8.06	82.0	27.4	4.0
6	Greece	Copper Slag	7.79	158.0	23.8	57.0
7	Greece	Copper Slag	6.20	85.0	20.6	21.5
8	Singapore	Copper Slag	6.07	64.0	4.8	17.0
9	Australia	Garnet	5.17	112.0	14.2	30.5
10	U.K.	Copper Slag	3.19	60.0	8.2	1.0
11	Australia	Garnet	6.26	97.0	3.4	22.0
12	Norway	Olivine	4.39	71.0	3.7	1.0
13	Greece	Slag (i)	84.00	532.0	47.6	258.0
14	Greece	Slag (i)	7.24	127.0	12.3	55.5
15	Greece	Slag (i)	6.50	78.0	4.6	23.0
16	Greece	Slag (i)	8.75	130.0	13.7	46.5
17	Greece	Slag (i)	8.28	169.0	17.8	71.5
18	Greece	Slag (i)	55.00	810.0	91.9	385.0
19	Norway	Olivine	4.80	113.0	19.2	40.5
20	Spain	Slag (i)	25.00	138.0	21.5	26.0
21	Spain	Slag (i)	31.00	191.0	26.6	30.5

TABLE 1

(i) Nature of slag unknown

COMPARISON OF ANALYSES  
OF AQUEOUS EXTRACTS

	Conductivity	T.D.S.	Sulphate	Chloride
Highest	13	18	18	18
	18	13	13	13
	21	21	3	17
	20	17	5	6
	3	6	21	14
	16	20	6	16
	17	16	20	19
	5	14	7	21
	6	19	19	9
	14	9	17	20
	15	3	4	15
	11	11	9	11
	7	7	16	7
	8	5	14	8
	4	15	2	3
	9	12	1	5
	19	8	10	4
	12	4	8	2
	10	10	15	1
	2	2	12	10
Lowest	1	1	11	12

=====

TABLE 2

N.B. Numbers in each column relate to Abrasive number identified in TABLE 1.



**TRANSFER RESULTS FROM BLAST CLEANING - COPPER SLAG (0.2-1.55mm)**

Abrasive Contamination Level mg/kg	Abrasive used kg/m2	Potential Chloride Transfer mg/m2	Actual Chloride Transfer mg/m2	% Transfer	Surface Conductivity mS/m
1.2	46.67	56.0	LT 0.5	See Note (i)	-
12.4	62.67	777.1	4.2	.54	.95
22.0	68.0	1496.0	6.6	.44	1.08
26.8	68.67	1840.0	7.8	.42	1.06
31.6	69.33	2190.8	8.9	.41	1.31
40.0	63.33	2533.2	11.1	.44	1.48
42.0	46.00	1932	10.6	.54	1.30
55.0	70.00	3850	16.2	.42	1.65
100.0	46.66	4660	18.1	.39	1.613
200.0	47.33	9466	40.6	.43	2.816
325.0	45.33	14732	68.6	.47	4.346

**TABLE 3**

**TRANSFER RESULTS FROM BLAST CLEANING - OLIVINE SAND (0.18-1.0mm)**

Abrasive Contamination Level mg/kg	Abrasive used kg/m2	Potential Chloride Transfer mg/m2	Actual Chloride Transfer mg/m2	% Transfer	Surface Conductivity mS/m
1.0	44.67	44.67	LT 0.5	See Note (i)	
49.0	45.33	2221.0	5.0	.23	1.76
95.0	43.33	4116.0	9.8	.24	1.96
200.0	46.0	9200.0	20.1	.22	2.53
360.0	45.33	16319.0	38.3	.24	3.52

**TABLE 4**

TRANSFER RESULTS FROM BLAST CLEANING - GARNET (0.2-0.6mm)

Abrasive Contamination Level mg/kg	Abrasive used kg/m2	Potential Chloride Transfer mg/m2	Actual Chloride Transfer mg/m2	% Transfer	Surface Conductivity mS/m
1.5	40.66	61.0	LT 0.5	See Note (i)	-
50.0	39.33	1967.0	8.3	.43	2.22
100.0	35.33	3533.0	24.1	.68	3.57
200.0	37.33	7466.0	44.5	.6	4.54
390.0	38.66	15077.0	68.9	.46	5.55

=====

TABLE 5

Note 1. Chloride transfer for unadulterated abrasives (nominally zero contamination) could not be monitored as the test method adopted and equipment limitations could not detect levels accurately below 0.5 mg/m2. No % transfer could therefore be calculated.



### FRESH WATER IMMERSION TESTS - RESULTS

Abrasive C1 Level	Surface Conductivity mS/m	Examination to ASTM D714		
		Time to Initial Blistering Hours	Condition of Immersed Area	
GARNET			Size	Density
1.5 ppm	-	144	8	few
50 ppm	2.22	72	8	"
100 ppm	3.57	55	8	"
200 ppm	4.54	31	8	few-medium
390 ppm	5.55	27	8	few

TABLE 6

### FRESH WATER IMMERSION TESTS - RESULTS

Abrasive C1 Level	Surface Conductivity mS/m	Examination to ASTM D714		
		Time to Initial Blistering Hours	Condition of Immersed Area	
OLIVINE			Size	Density
1.0 ppm	-	336	8	few
49 ppm	1.76	144	8	"
95 ppm	1.96	144	8	"
200 ppm	2.53	144	8	"
360 ppm	3.52	31	8	"

TABLE 7

### FRESH WATER IMMERSION TESTS - RESULTS

Abrasive C1 Level	Surface Conductivity mS/m	Examination to ASTM D714		
		Time to Initial Blistering Hours	Condition of Immersed Area	
COPPER SLAG			Size	Density
12.4 ppm	.95	144	8	few
22 ppm	1.08	144	8	"
26.8 ppm	1.06	144	8	"
31.6 ppm	1.31	360	8	"
40 ppm	1.48	144	8	"
55 ppm	1.65	144	8	"

TABLE 8

### FRESH WATER IMMERSION TESTS - RESULTS

Abrasive C1 Level	Surface Conductivity mS/m	Examination to ASTM D714		
		Time to Initial Blistering Hours	Condition of Immersed Area	
COPPER SLAG			Size	Density
1.2 ppm	-	384	8	few
42 ppm	1.30	384	8	"
100 ppm	1.61	288	8	"
200 ppm	2.82	72	8	"
325 ppm	4.35	31	8	few-medium

TABLE 9



**CONTAMINATION TRANSFER AS A FUNCTION  
OF GRITBLASTING DURATION**

ABRASIVE	ABRASIVE CONTAMINATION LEVEL MG/KG (CL)	BLAST DURATION x STANDARD BLAST TIME	ABRASIVE USED KG/M <sup>2</sup>	POTENTIAL CL- TRANSFER WT MG/M <sup>2</sup>	ACTUAL CL- TRANSFER WT MG/M <sup>2</sup>	CONDUCTIVITY	
						ABRASIVE MS/M	SURFACE
COPPER SLAG (0.2-0.7mm)	1.1	1.	48.00	52.8	0.71	8.0	1.13
		2.	99.38	109.32	0.55	8.0	1.13
		3.	138.67	152.54	0.61	8.0	1.40
	23	1.	50.00	1150	7.7	15.0	1.22
		2.	104.00	2392	9.6	15.0	1.42
		3.	160.00	3680	8.9	15.0	1.51
	47	1.	50.66	2381.02	13.0	21.0	1.57
		2.	107.34	5044.98	13.7	21.0	1.77
		3.	150.67	7081.49	11.9	21.0	1.56
	75	1.	49.34	3700.5	16.6	33.0	1.71
		2.	101.34	7600.5	18.4	33.0	1.92
		3.	136.00	10200.0	18.7	33.0	2.06
OLIVINE (0.125-0.5mm)	2.7	1.	51.34	138.62	1.4	13.0	1.75
		2.	108.00	291.6	1.1	13.0	1.91
		3.	152.67	412.21	1.0	13.0	2.01
	23	1.	46.67	1073.41	6.1	22.0	2.20
		2.	100.67	2315.41	4.7	22.0	2.37
		3.	124.67	2867.41	3.9	22.0	2.29
	40	1.	47.34	1893.6	13.2	32.0	2.53
		2.	102.67	4106.8	12.1	32.0	3.12
		3.	134.67	5386.8	12.0	32.0	2.82
	69	1.	48.67	3358.23	14.8	42.0	2.79
		2.	102.67	7084.23	13.6	42.0	3.14
		3.	140.00	9660.00	13.1	42.0	2.87
GARNET (0.2-0.6mm)	3.9	1.	52.67	205.41	1.2	7.0	1.44
		2.	107.34	418.63	0.9	7.0	1.08
		3.	150.00	585.00	0.8	7.0	1.11
	24	1.	54.67	1312.08	3.4	12.0	1.31
		2.	118.00	2832.00	2.1	12.0	1.13
		3.	156.00	3744.00	2.0	12.0	0.99
	48	1.	52.00	2496.00	5.2	18.0	1.25
		2.	109.34	5248.32	5.1	18.0	1.28
		3.	145.34	6976.32	5.0	18.0	1.35
	70	1.	54.67	3826.9	8.3	25.0	1.43
		2.	114.00	7980.00	7.6	25.0	1.45
		3.	157.34	11013.8	6.1	25.0	1.24

TABLE 10

**CONDUCTIVITY AND CHLORIDE DETERMINATIONS  
ON WATER EXTRACTS, OF UNCRUSHED AND CRUSHED ABRASIVES**

ABRASIVE	COLD EXTRACT		HOT EXTRACT (100°C)	
	UNCRUNSHED	CRUSHED	UNCRUNSHED	CRUSHED
<u>COPPER SLAG</u>				
CONDUCTIVITY mS/m	8.0	16.0	10.0	16.0
CHLORIDE ppm	1.4	7.7	3.8	9.3
<u>OLIVINE SAND</u>				
CONDUCTIVITY mS/m	13.0	25.0	16.0	35.0
CHLORIDE ppm	2.5	8.1	7.7	7.7
<u>GARNET-AUSTRALIAN (i)</u>				
CONDUCTIVITY mS/m	7.0	15.0	15.0	16.0
CHLORIDE ppm	3.9	5.4	5.5	5.6
<u>GARNET-AUSTRALIAN (ii)</u>				
CONDUCTIVITY mS/m	9.0	18.0	13.0	19.0
CHLORIDE ppm	14.5	15.8	17.0	17.1
<u>GARNET-INDIAN (i)</u>				
CONDUCTIVITY mS/m	8.0	16.0	11.0	20.0
CHLORIDE ppm	7.0	8.7	7.5	9.2
<u>GARNET-INDIAN (ii)</u>				
CONDUCTIVITY mS/m	46.0	60.0	59.0	67.0
CHLORIDE ppm	140	180	160	204
<u>GARNET-AMERICAN</u>				
CONDUCTIVITY mS/m	5.0	9.0	6.0	11.0
CHLORIDE ppm	2.7	4.7	1.6	3.2

TABLE 11



**PARTICULATE SIZE ANALYSIS, CONDUCTIVITY DETERMINATIONS,  
CHLORIDE AND SULPHATE DETERMINATIONS, ON VIRGIN AND CRUSHED ABRASIVES**

Mesh Size (Microns)	COPPER SLAG				OLIVINE SAND				AUSTRALIAN GARNET			
	Virgin Unground	Lightly Ground	Moderately Ground	Well Ground	Virgin Unground	Lightly Ground	Moderately Ground	Well Ground	Virgin Unground	Lightly Ground	Moderately Ground	Well Ground
	Sieve Analysis Cumulative PERCENT PASSING				Sieve Analysis Cumulative PERCENT PASSING				Sieve Analysis Cumulative PERCENT PASSING			
1000	99	100	100	100	100	100	100	100	100	100	100	100
850	96	98	100	100	98	100	100	100	100	100	100	100
600	66	85	96	100	84	98	99	100	99	100	100	100
300	19	45	65	90	13	61	77	93	34	71	84	97
250		38	59	85	9	51	70	87	16	58	76	93
150		23	39	66	3	28	44	61	0	27	45	68
90		12	25	44	1	15	26	39	0	14	27	47

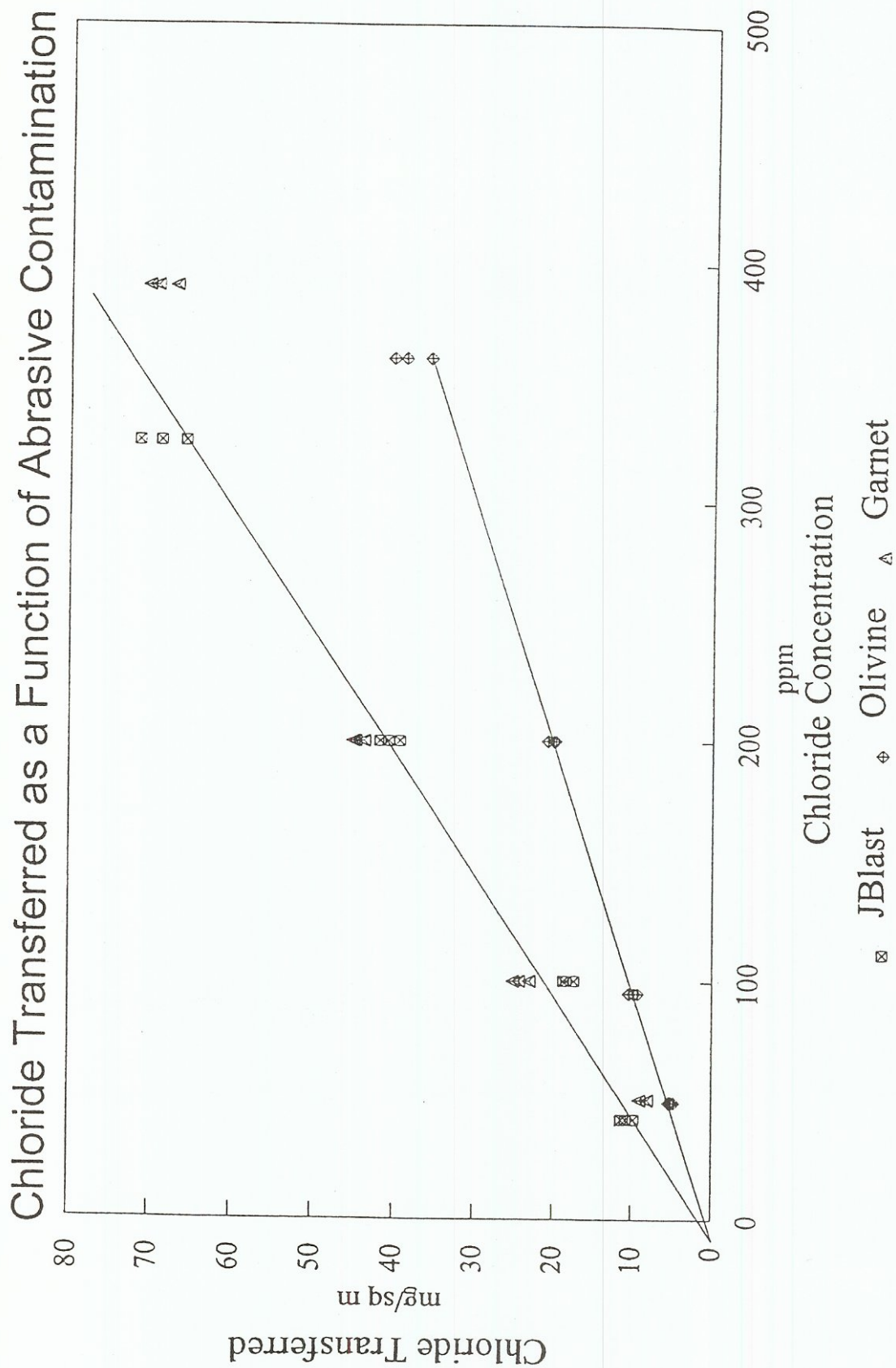
Conductivity (mS/m)	9	11	13	16	15	21	25	27	7	9	11	15
------------------------	---	----	----	----	----	----	----	----	---	---	----	----

Chloride (mg/kg)	2.4	3.1	4.5	7.4	2.8	3.1	3.7	5.7	6.0	5.7	5.6	5.2
---------------------	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

Sulphate (mg/kg)	10	11	13	18	25	28	35	46	9	11	18	28
---------------------	----	----	----	----	----	----	----	----	---	----	----	----

TABLE 12

GRAPH I





GRAPH II

