



# G&S VALVES LTD

Alder Works, Catteshall Lane, Godalming, Surrey, England. GU7 1JS

Telephone +44 (0) 1 483 415444 Fax +44 (0) 1 483 426891

E-Mail: [GSValves@aol.com](mailto:GSValves@aol.com), Web: <http://www.gsvalves.co.uk>

## Technical Information



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## Technical Information

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## Contact Information

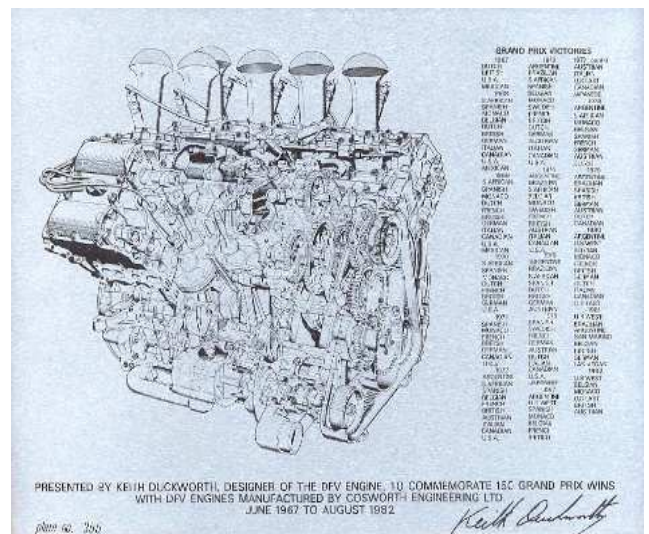
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# Company Profile

**Established 1946**

G&S Valves Ltd. specialises in manufacturing a wide range of valves, from 'one off' prototypes for engine development, up to ongoing scheduled contracts for larger companies. We have received approved supplier status from many of the major OEM and high performance manufacturers.

Cosworth 'Approved Supplier Scheme',  
Rolls Royce Motor Cars 'Supplier Assessments',  
Varity Perkins 'Approved Supplier'  
and  
Various Vintage Motor Car & Motorcycle Clubs.



# Company History

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G&S Valves Ltd. was founded on July 13th 1946 by Mr. Harry Grenside and his partner Mr. Ralph Saunders, the company was originally known as G&S Motors located in a small factory in Milford, Surrey, England.

In 1947 G&S Valves acquired its first major customer, Petters of Staines. By 1959 the work load had increased so much that new premises had to be found. This was to be a purpose built factory in Catteshall Lane, Godalming, when the name changed to G&S Valves.

Over the next few years the range of valves produced was increased to include those for competition engines and racing cars as well as for the English motor cycle industry. During this time they earned a reputation as a high quality engine valve manufacturer,

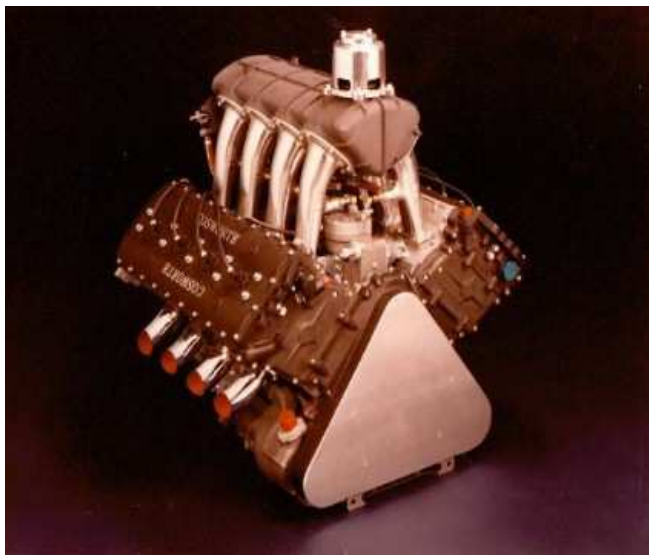
supplying the likes of:

Cosworth Racing

Lotus

Ford Competition Department  
and many others.

In 1974 Mr. Robert Grenside & Mr. Neville Nichols took over control of G&S Valves Ltd. and continued to improve quality of the valves produced. 1980 saw the purchase of a Forge, based in the West Midlands, which Mr. Trevor Abbotts, formally from TRW, took control of this new acquisition allowing us to make purpose made forgings for the ever increasing valve business.



Due to the increasing complexity of some of the shapes required by some of our racing customers, G&S Valves had to purchase a number of CNC Lathes and Grinders to produce these new designs. With this came the need to install a CAD system to create the drawings needed.

In 1991 Mr. Andrew Grenside joined the company and used his knowledge in computers to set up this new system. This new set-up has improved the production techniques and quality of all of valves produced at G&S, and is looking forward to new challenges in the forthcoming years.



# General Overview

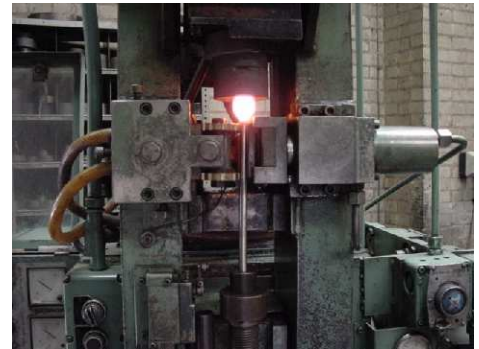
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G&S Valves Ltd. can offer you a complete valve, from start to finish.

We hold a comprehensive stock of high quality valve steel and can upset forgings from a vast range of die forms to produce suitably close limit forgings to suit most applications.



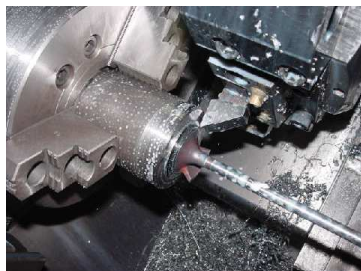
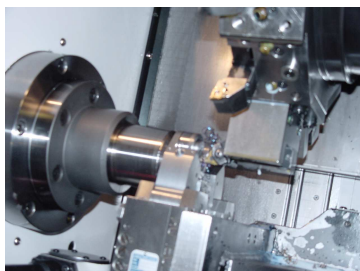
We have the facilities to perform various types of heat treatments, bi-metal valves and Armored Seated Valves (Cobalt based deposit - Grade 6).



Our manufacturing process starts life as a plain steel rod which is then electrically upset to form a bunt, then forged into a close limit forging.



After being forged the valve goes through a number of machining and grinding operations.

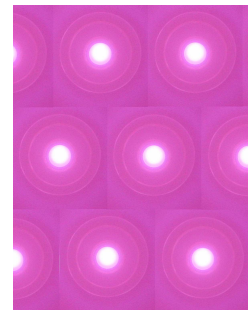
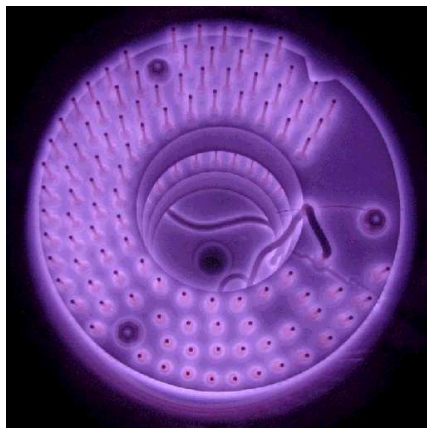


## General Overview - continued -

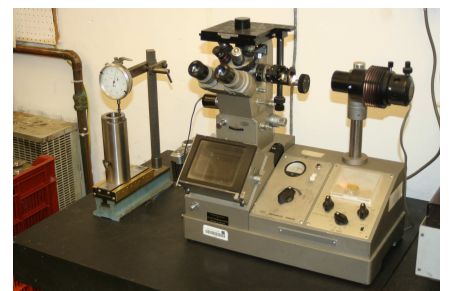
Before final inspection in our quality department.



After final inspection,  
we can offer a pulsed plasma treatment (in house)  
as well as various other treatments.



Surface Hardness is then checked in our metallurgy lab.



# Material Cross Reference

|             | England      |       | Sweden | USA     | Germany |                 | France        | Belgium   | Italy       | Spain  | Japan     |
|-------------|--------------|-------|--------|---------|---------|-----------------|---------------|-----------|-------------|--------|-----------|
| G&S Valves  | British Std. | EN    | SS     | AIS/SAE | W.-nr   | DIN             | AFNOR         | NBN       |             | UNF    | JIS       |
| EN18        | 530M40       | EN18  |        | 5140    | 1.7035  | 41Cr4           | 42C4          | 41Cr4     | 41Cr4       | 42Cr4  | SCr44 (H) |
| EN24        | 817M40       | EN24  | 2541   | 5340    | 1.6582  | 34CrNiMo6       | 35NCD6        | 35NiCrMo6 | 35NiCrMo6   |        |           |
| EN31        | 534A99       | EN31  | 2258   | 52100N  | 1.3505  | 100Cr6          | 100C6         |           | 100Cr6      | F.131  | SUJ2      |
| EN52        | 401S45       | EN52  |        | HW3     | 1.4718  | X45CrSi93       | Z45CS9        |           | X45CrSi8    | F.322  | SUH1      |
| EN54A       | 331S42       | EN54A | S      |         | 1.2731  | X80CrNiSi20     |               |           |             |        |           |
| EN59        | 443S65       | EN59  |        | HNV6    | 1.4747  | X80CrNiSi20     | Z80CSN20.02   |           | X80CrSiNi20 | F.320B | SUH4      |
| 214N        | 349S52       |       |        | EV8     | 1.4871  | X53CrMnNi219    | Z55CMN21.09   |           | X53CrMnNiN  | F.3551 | SUH35     |
| X21RB       | 352S52       |       |        |         | 1.4870  | X53CrMnNiNb219  | Z50CMNNb21.09 |           |             |        |           |
| 1.4882      |              |       |        |         | 1.4882  | X50CrMnNiNbN219 |               |           |             |        |           |
| 1.4731      |              |       |        |         | 1.4731  | X40CrSiMo102    | Z40CSD10      |           |             |        | SUH3      |
| 1.3343      | BM2          |       | 2722   |         | 1.3343  | S6-5-2          | HS6-5-2       |           |             |        | SKIH51    |
| Nimonic 80A | 3076         | 2188  |        | HEV5    | 2.4952  | 17742           | NC20TA        |           |             |        | SUH751    |
| 316S11      |              |       |        |         | 1.4404  | X2CrNiMo17132   | Z2CND1712     |           | X2CrNiMo17  |        |           |

# Mechanical Properties

## Tensile Strength, Proof Stress & Creep Strength

| Material                                                                                                                                                                                                  | Tensile Strength<br>(N/ sq. mm) |           | 0.2% Proof Stress<br>(Yield Strength) N/sq. mm |           | Creep Strength<br>(after 1000 h) N/sq. mm |     |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|-----------|------------------------------------------------|-----------|-------------------------------------------|-----|
| 214N - (349S52)                                                                                                                                                                                           | 500 Deg.C.                      | 650       | 500 Deg.C.                                     | 350       | 650 Deg.C.                                | 200 |
|                                                                                                                                                                                                           | 550 Deg.C.                      | 600       | 550 Deg.C.                                     | 330       | 725 Deg.C.                                | 110 |
|                                                                                                                                                                                                           | 600 Deg.C.                      | 550       | 600 Deg.C.                                     | 300       | 800 Deg.C.                                | 50  |
|                                                                                                                                                                                                           | 650 Deg.C.                      | 500       | 650 Deg.C.                                     | 270       |                                           |     |
|                                                                                                                                                                                                           | 700 Deg.C.                      | 450       | 700 Deg.C.                                     | 250       |                                           |     |
|                                                                                                                                                                                                           | 750 Deg.C.                      | 370       | 750 Deg.C.                                     | 230       |                                           |     |
|                                                                                                                                                                                                           | 800 Deg.C.                      | 300       | 800 Deg.C.                                     | 200       |                                           |     |
| 1.4882                                                                                                                                                                                                    | 500 Deg.C.                      | 680       | 500 Deg.C.                                     | 350       | 650 Deg.C.                                | 220 |
|                                                                                                                                                                                                           | 550 Deg.C.                      | 650       | 550 Deg.C.                                     | 330       | 725 Deg.C.                                | 120 |
|                                                                                                                                                                                                           | 600 Deg.C.                      | 610       | 600 Deg.C.                                     | 310       | 800 Deg.C.                                | 55  |
|                                                                                                                                                                                                           | 650 Deg.C.                      | 550       | 650 Deg.C.                                     | 285       |                                           |     |
|                                                                                                                                                                                                           | 700 Deg.C.                      | 480       | 700 Deg.C.                                     | 260       |                                           |     |
|                                                                                                                                                                                                           | 750 Deg.C.                      | 410       | 750 Deg.C.                                     | 240       |                                           |     |
|                                                                                                                                                                                                           | 800 Deg.C.                      | 340       | 800 Deg.C.                                     | 220       |                                           |     |
| 352S52                                                                                                                                                                                                    | 500 Deg.C.                      | 680       | 500 Deg.C.                                     | 340       | 650 Deg.C.                                | 215 |
|                                                                                                                                                                                                           | 550 Deg.C.                      | 650       | 550 Deg.C.                                     | 320       | 725 Deg.C.                                | 115 |
|                                                                                                                                                                                                           | 600 Deg.C.                      | 600       | 600 Deg.C.                                     | 310       | 800 Deg.C.                                | 50  |
|                                                                                                                                                                                                           | 650 Deg.C.                      | 510       | 650 Deg.C.                                     | 280       |                                           |     |
|                                                                                                                                                                                                           | 700 Deg.C.                      | 450       | 700 Deg.C.                                     | 260       |                                           |     |
|                                                                                                                                                                                                           | 750 Deg.C.                      | 380       | 750 Deg.C.                                     | 235       |                                           |     |
|                                                                                                                                                                                                           | 800 Deg.C.                      | 320       | 800 Deg.C.                                     | 220       |                                           |     |
| 316S11                                                                                                                                                                                                    |                                 |           |                                                |           |                                           |     |
| EN24 - (817M40)                                                                                                                                                                                           | 1180 – 1380                     |           | 980                                            |           |                                           |     |
| EN31 - (534A99)                                                                                                                                                                                           |                                 |           |                                                |           |                                           |     |
| 1.3343                                                                                                                                                                                                    |                                 |           |                                                |           |                                           |     |
| EN52 - (401S45)                                                                                                                                                                                           | 500 Deg.C.                      | 500       | 500 Deg.C.                                     | 400       | 500 Deg.C.                                | 190 |
|                                                                                                                                                                                                           | 550 Deg.C.                      | 360       | 550 Deg.C.                                     | 300       | 650 Deg.C.                                | 40  |
|                                                                                                                                                                                                           | 600 Deg.C.                      | 250       | 600 Deg.C.                                     | 240       |                                           |     |
|                                                                                                                                                                                                           | 650 Deg.C.                      | 170       | 650 Deg.C.                                     | 120       |                                           |     |
|                                                                                                                                                                                                           | 700 Deg.C.                      | 110       | 700 Deg.C.                                     | 80        |                                           |     |
|                                                                                                                                                                                                           | Not use above 700 Deg.C.        |           | Not use above 700 Deg.C.                       |           | Not use above 700 Deg.C.                  |     |
|                                                                                                                                                                                                           |                                 |           |                                                |           |                                           |     |
| EN59 - (443S65)                                                                                                                                                                                           | 20 Deg.C.                       | 1080      | 20 Deg.C.                                      | 900       |                                           |     |
|                                                                                                                                                                                                           | 600 Deg.C.                      | 400       | 600 Deg.C.                                     | 300       |                                           |     |
|                                                                                                                                                                                                           | 700 Deg.C.                      | 175       | 700 Deg.C.                                     | 150       |                                           |     |
|                                                                                                                                                                                                           | 800 Deg.C.                      | 115       | 800 Deg.C.                                     | 75        |                                           |     |
| EN54A (331S42)                                                                                                                                                                                            | Ultimate Strength               |           | Yield Point                                    |           |                                           |     |
|                                                                                                                                                                                                           | 20 Deg.C.                       | 818 - 926 | 20 Deg.C.                                      | 509 - 556 |                                           |     |
|                                                                                                                                                                                                           | 600 Deg.C.                      | 463 - 494 | 600 Deg.C.                                     | 278 - 309 |                                           |     |
|                                                                                                                                                                                                           | 700 Deg.C.                      | 417 - 448 | 700 Deg.C.                                     | 216 - 231 |                                           |     |
|                                                                                                                                                                                                           | 800 Deg.C.                      | 247 - 262 | 800 Deg.C.                                     | 123 - 139 |                                           |     |
|                                                                                                                                                                                                           | 1000 Deg.C.                     | 77 - 92   | 1000 Deg.C.                                    | 38 - 46   |                                           |     |
| Nimonic (80A)<br>* Note: Nimonic has an<br>undesirable operating range<br>of between 750-775 Deg. C<br>(top end of sulphur corrosion<br>overlapping into the bottom<br>end of the oxidation<br>corrosion) | 500 Deg.C.                      | 1050      | 500 Deg.C.                                     | 700       | 650 Deg.C.                                | 500 |
|                                                                                                                                                                                                           | 550 Deg.C.                      | 1030      | 550 Deg.C.                                     | 650       | 725 Deg.C.                                | 290 |
|                                                                                                                                                                                                           | 600 Deg.C.                      | 1000      | 600 Deg.C.                                     | 650       | 800 Deg.C.                                | 150 |
|                                                                                                                                                                                                           | 650 Deg.C.                      | 930       | 650 Deg.C.                                     | 600       |                                           |     |
|                                                                                                                                                                                                           | 700 Deg.C.                      | 820       | 700 Deg.C.                                     | 600       |                                           |     |
|                                                                                                                                                                                                           | 750 Deg.C. *                    | 680 *     | 750 Deg.C. *                                   | 500 *     |                                           |     |
|                                                                                                                                                                                                           | 800 Deg.C.                      | 500       | 800 Deg.C.                                     | 450       |                                           |     |
| Armored Seat - Cobalt<br>based deposit - Grade 6                                                                                                                                                          | 600 Deg.C.                      | 1000      |                                                |           |                                           |     |
| Tips - Cobalt based<br>deposit - Grade 12                                                                                                                                                                 | 99 kg/mm^2                      |           |                                                |           |                                           |     |

## Mechanical Properties - continued –

### Modulus of Elasticity, Elongation and Reduction in Area

| Material                                         | Modulus of Elasticity<br>@20 Deg.C.<br>kN/sq. mm | Elongation after Fracture<br>(L=5d) <sup>2</sup><br>E %                                                    | Reduction in Area<br>after Fracture<br>RA % |
|--------------------------------------------------|--------------------------------------------------|------------------------------------------------------------------------------------------------------------|---------------------------------------------|
| 214N (349S52)                                    | 205                                              | 8                                                                                                          | 10                                          |
| 1.4882                                           | 205                                              | 12                                                                                                         | 15                                          |
| 352S52                                           | 205                                              | 8                                                                                                          | 10                                          |
| EN52 (401S45)                                    | 210                                              | 14                                                                                                         | 40                                          |
| EN59 (443S65)                                    | 200                                              | 15                                                                                                         | 15                                          |
| EN54A (331S42)                                   | 203                                              | 20 Deg.C. 25 - 32<br>600 Deg.C. 20 - 25<br>700 Deg.C. 24 - 28<br>800 Deg.C. 35 - 40<br>1000 Deg.C. 60 - 65 | 20 - 25                                     |
| EN24 (817M40)                                    | 210                                              | 9                                                                                                          | 40                                          |
| 1.3343                                           | 217                                              |                                                                                                            |                                             |
| Nimonic (80A)                                    | 215                                              | 15                                                                                                         | 25                                          |
| 316S11                                           |                                                  |                                                                                                            |                                             |
| Armored Seat - Cobalt<br>based deposit - Grade 6 | 210                                              |                                                                                                            |                                             |
| Tips - Cobalt based<br>deposit - Grade 12        | 204                                              |                                                                                                            |                                             |

- Tensile Strength** - The maximum load applied in breaking a tensile test piece divided by the original cross-sectional area of the test piece.  
(The maximum stress value obtained on a stress-strain curve)
- Ultimate Strength** - Is the maximum stress value obtained on a stress-strain curve.
- Yield Strength** - The maximum stress that can be applied without permanent deformation.
- Yield Point** - Is a point on the stress-strain curve at which there is a sudden increase in strain without a corresponding increase in stress.
- Creep Strength** - Continuing changes in dimensions of a stressed material over time, a constant tensile load is applied under a specified temperature.  
(This is not Creep Rupture - which is when the material fails).
- Modulus of Elasticity** - The ratio of unit stress to unit strain within the proportional limit of a material in shear.

# Chemical Properties

## % Chemical Composition

| Material                      | C            | Si           | Mn           | Ni             | Cr             | N            | S            | P            | Cu         | Fe       | Ti         | Al         | Co       | B            | Zr          | Pb            | Nb<br>Ta     | W            | Mo           | O2 | V    | H2 | Sn |
|-------------------------------|--------------|--------------|--------------|----------------|----------------|--------------|--------------|--------------|------------|----------|------------|------------|----------|--------------|-------------|---------------|--------------|--------------|--------------|----|------|----|----|
| Austinitic Stainless Steel    |              |              |              |                |                |              |              |              |            |          |            |            |          |              |             |               |              |              |              |    |      |    |    |
| 214N<br>(349S52)              | 0.48<br>0.58 | 0.25<br>Max  | 8<br>10      | 3.25<br>4.50   | 20<br>22       | 0.35<br>0.50 | 0.03<br>Max  | 0.045<br>Max |            | Bal      |            |            |          |              |             |               |              |              |              |    |      |    |    |
| 352S52                        | 0.48<br>0.58 | 0.45<br>Max  | 8<br>10      | 3.25<br>4.50   | 20<br>22       | 0.38<br>0.50 | 0.035<br>Max | 0.04<br>Max  |            | Bal      |            |            |          |              |             |               | 2.00<br>3.00 |              |              |    |      |    |    |
| 1.4882                        | 0.45<br>0.55 | 0.45<br>Max  | 8<br>10      | 3.50<br>5.50   | 20<br>22       | 0.40<br>0.60 | 0.030<br>Max | 0.045<br>Max |            | Bal      |            |            |          |              |             |               | 1.80<br>2.50 | 0.80<br>1.50 |              |    |      |    |    |
| Stainless Steel               |              |              |              |                |                |              |              |              |            |          |            |            |          |              |             |               |              |              |              |    |      |    |    |
| 316S11                        | 0.03         | 1.0          | 2.0          | 11<br>14       | 16.5<br>18.5   |              | 0.03         | 0.045        |            | Bal      |            |            |          |              |             |               |              |              | 2.00<br>2.50 |    |      |    |    |
| Wrought Steel (EN Series)     |              |              |              |                |                |              |              |              |            |          |            |            |          |              |             |               |              |              |              |    |      |    |    |
| EN24<br>(817M40)              | 0.35<br>0.44 | 0.10<br>0.35 | 0.45<br>0.70 | 1.30<br>1.70   | 1.00<br>1.40   |              | 0.04<br>Max  | 0.04<br>Max  |            | Bal      |            |            |          |              |             |               |              |              | 0.20<br>0.35 |    |      |    |    |
| EN52<br>(401S45)              | 0.40<br>0.50 | 2.70<br>3.30 | 0.60<br>Max  | 0.50<br>Max    | 8<br>10        |              | 0.03<br>Max  | 0.04<br>Max  |            | Bal      |            |            |          |              |             |               |              |              |              |    |      |    |    |
| EN59<br>(443S65)              | 0.75<br>0.85 | 1.75<br>2.25 | 0.30<br>0.75 | 1.20<br>1.70   | 19<br>21       |              | 0.40<br>Max  | 0.40<br>Max  |            | Bal      |            |            |          |              |             |               |              |              |              |    |      |    |    |
| EN54A<br>(331S42)             | 0.45         | 1.37<br>1.45 | 0.59<br>0.96 | 13.52<br>13.70 | 13.58<br>14.40 |              |              |              |            | Bal      |            |            |          |              |             |               |              | 2.17<br>2.42 |              |    |      |    |    |
| 1.3343                        | 0.90         | 0.23         | 0.20         |                | 4.15           |              |              |              |            | Bal      |            |            |          |              |             |               |              | 6.35         | 4.95         |    | 1.85 |    |    |
| Nimonic Alloys                |              |              |              |                |                |              |              |              |            |          |            |            |          |              |             |               |              |              |              |    |      |    |    |
| Nimonic<br>(80A)              | 0.04<br>0.10 | 1.0<br>Max   | 1.0<br>Max   | 65<br>Min      | 18<br>21       |              | 0.015<br>Max | 0.020<br>Max | 0.2<br>Max | 3<br>Max | 1.8<br>2.7 | 1.0<br>1.8 | 2<br>Max | 0.008<br>Max | 0.15<br>Max | 0.0025<br>Max |              |              |              |    |      |    |    |
| Cobalt Based Alloys           |              |              |              |                |                |              |              |              |            |          |            |            |          |              |             |               |              |              |              |    |      |    |    |
| Armored<br>Seats -<br>Grade 6 | 1.1          |              |              | <3.0           | 28             |              |              |              |            | <3.0     |            |            | Bal      |              |             |               |              | 5.0          |              |    |      |    |    |
| Tips<br>Grade 12              | 0.9          | 2.5          |              | 13             | 19             |              |              |              |            | <3.0     |            |            | Bal      | 1.8          |             |               |              | 9.0          |              |    |      |    |    |

C - Carbon

N – Nitrogen

Ti – Titanium

Pb - Lead

O - Oxygen

Zn - Zinc

Si – Silicon

S - Sulfur

Al – Aluminum

Nb - Niobium

V - Vanadium

Mn - Manganese

P – Phosphorus

Co - Cobalt

Ta – Tantalum

H - Hydrogen

Ni - Nickel

Cu - Copper

B – Boron

W - Tungsten

Sn - Tin

Cr – Chromium

Fe – Iron

Zr – Zirconium

Mo – Molybdenum

Mg – Magnesium

## Chemical Properties - *continued* –

### Proof Stress & Creep Strength

| Material                             | Melting Point | Corrosion at @900 Deg. C with Lead Oxide (g/dm <sup>2</sup> /h) |
|--------------------------------------|---------------|-----------------------------------------------------------------|
| 214N (349S52)                        | 1,420 Deg. C  | 18                                                              |
| 1.4882                               | 1,420 Deg. C  |                                                                 |
| 352S52                               | 1,420 Deg. C  |                                                                 |
| EN52 (401S45)                        | 1,457 Deg. C  | 54                                                              |
| EN54A (331S42)                       |               |                                                                 |
| EN59 (443S65)                        | 1,408 Deg. C  | 51                                                              |
| EN24 (817M40)                        |               |                                                                 |
| 1.3343                               |               |                                                                 |
| Nimonic (80A)                        | 1,343 Deg. C  | 3                                                               |
| 316S11                               |               |                                                                 |
| Armored Seats – Cobalt Based Grade 6 | 1,290 Deg. C  |                                                                 |

# Chemical Properties - *continued* –

## Material Characteristics

### **Chemical Composition:**

The initial assessment of any group of steel is by chemical analysis and the main alloys used in Valve Steels are,

#### **Chromium: (Cr)**

The most valuable element for improving the corrosion and oxidation resistance of steel, particularly against sulphur in any form, or in combination with hydrogen or with organic compounds. It is considered that under oxidising conditions, a thin tenacious surface layer of chromium oxide is formed which provides a skin impervious to further oxidation. This protective surface remains constant, preventing any penetration of the general body of the steel. As an alloying element, chromium has advantages over others, such as silicon and aluminium, both of which improve oxidation resistance but are less satisfactory in the presence of reducing atmospheres and/or sulphur attack..

#### **Nickel: (Ni)**

In the higher additions, nickel improves oxidation resistance, especially in the presence of chromium, but has little effect when present at values below 2%. This element has a considerable effect on toughness and depth of hardening of the martensitic steels. High nickel steels are prone to attack by sulphurous atmospheres due to intergranular formation of nickel sulphide.

#### **Silicon: (Si)**

This element leads to improvement in strength and resistance to oxidation but is on occasions responsible for manipulation difficulties and brittleness due to grain coarsening. In certain ranges of composition, silicon contributes to lack of uniformity in mechanical properties.

#### **Molybdenum: (Mo)**

An element generally regarded as an additive to promote fine grain and to confer an increase in resistance to temper brittleness. It has a beneficial effect on high temperature strength.

#### **Vanadium: (V)**

This is a grain refining and toughening element, which also contributes towards high temperature strength.

#### **Tungsten: (W)**

This element has a beneficial effect on high temperature strength and was one of the first elements used for this purpose.

#### **Nitrogen: (N)**

This element has a beneficial effect on improving hardness.

#### **Niobium: (Nb)**

This element has a beneficial effect on refining the grain size.

# Physical Properties

## Hot Forming Temperature, Thermal Conductivity, Specific Heat Capacity & Coefficient of Thermal Expansion

| Material                                       | Hot Forming Temperature | Thermal Conductivity W/(m.K) | Specific Heat Capacity J/Kg. K | Mean coefficient of Thermal Expansion * 10 exp(-6).K(-1) |      |
|------------------------------------------------|-------------------------|------------------------------|--------------------------------|----------------------------------------------------------|------|
| 214N (349S52)                                  | 1150-950 Deg C          | 14.5                         | 500                            | 100 Deg.C                                                | 15.5 |
|                                                |                         |                              |                                | 300 Deg.C                                                | 17.5 |
|                                                |                         |                              |                                | 500 Deg.C                                                | 18.5 |
|                                                |                         |                              |                                | 700 Deg.C                                                | 18.8 |
| 1.4882                                         | 1150-950 Deg C          | 14.5                         | 500                            | 100 Deg C                                                | 15.5 |
|                                                |                         |                              |                                | 300 Deg C                                                | 17.5 |
|                                                |                         |                              |                                | 500 Deg C                                                | 18.5 |
|                                                |                         |                              |                                | 700 Deg C                                                | 18.8 |
| 352S52                                         | 1150-980 Deg C          | 14.5                         | 500                            | 100 Deg C                                                | 15.5 |
|                                                |                         |                              |                                | 300 Deg C                                                | 17.5 |
|                                                |                         |                              |                                | 500 Deg C                                                | 18.5 |
|                                                |                         |                              |                                | 700 Deg C                                                | 18.8 |
| 316S11                                         |                         |                              |                                |                                                          |      |
| EN24 (817M40)                                  |                         | 37.7                         | 460                            |                                                          |      |
| EN31 (534A99)                                  | 1050-850 Deg C          |                              |                                |                                                          |      |
| EN52 (401S45)                                  | 1100- 900 Deg C         | 21                           | 500                            | 100 Deg C                                                | 10.9 |
|                                                |                         |                              |                                | 300 Deg C                                                | 11.2 |
|                                                |                         |                              |                                | 500 Deg C                                                | 11.5 |
|                                                |                         |                              |                                | 700 Deg C                                                | 11.8 |
| EN54A (331S42)                                 | 1200 - 950 Deg C        |                              |                                |                                                          |      |
| 1.3343                                         | 1100 - 900 Deg C        | 19                           | 460                            | 100 Deg C                                                | 11.5 |
|                                                |                         |                              |                                | 300 Deg C                                                | 12.2 |
|                                                |                         |                              |                                | 500 Deg C                                                | 12.7 |
|                                                |                         |                              |                                | 700 Deg C                                                | 12.9 |
| EN59 (443S65)                                  |                         |                              |                                |                                                          |      |
| Nimonic (80A)                                  | 1150-1050 DegC          | 13                           | 460                            | 100 Deg C                                                | 11.9 |
|                                                |                         |                              |                                | 300 Deg C                                                | 13.1 |
|                                                |                         |                              |                                | 500 Deg C                                                | 13.7 |
|                                                |                         |                              |                                | 700 Deg C                                                | 14.5 |
| Armored Seats - Cobalt based deposit - Grade 6 |                         |                              | 0.101 cal/g. C                 | 50 – 600 Deg C 15.3                                      |      |
| Tips - Cobalt based deposit - Grade 12         |                         |                              | 0.098 cal/g. C                 | 50 – 600 Deg C 14.1                                      |      |

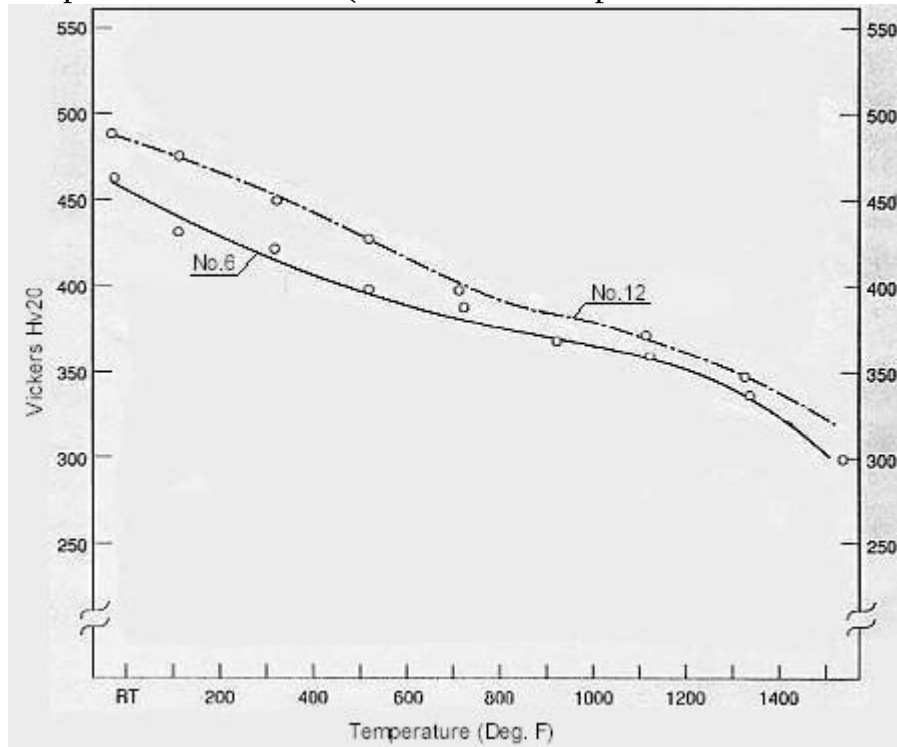
Specific Heat -is the ratio of heat required to raise the temperature of a certain weight of material by 1 Deg C to that required to raise the temperature of the same weight of water by 1 Deg C

Coefficients of Thermal Expansion for Valve Guide Material (between 0 and 200 Deg C, in 10 exp(-6).K(-1))  
Cast Iron 11, Phosphor Bronze 18, Aluminum Bronze 18

**Note** :- To find the expansion at 300 Deg C of a valve with a stem diameter of 0.275” in 214N material.  
(Assuming the stem diameter was measured at 20 Deg. C)  
the temperature difference is (300 Deg C - 20 Deg C) = 280 Deg C  
stem diameter x temperature difference x coefficient of thermal expansion = Expansion of Valve  
ie: 0.275” x 280 x 0.0000175 = 0.0013”

## Physical Properties - continued -

### High Temperature Hardness (Cobalt based deposit - Grade 6 No.6 & 12)



### Volumetric Weight

| Material +/- 0.5 Grams | Volumetric Weight               |
|------------------------|---------------------------------|
| 214N - (349S52)        | 7.74 g/cc x (16.38706 x Volume) |
| 1.4882                 | 7.81 g/cc x (16.38706 x Volume) |
| 352S52                 |                                 |
| Nimonic (80A)          | 8.19 g/cc x (16.38706 x Volume) |
| EN59 (443S65)          | 7.74 g/cc x (16.38706 x Volume) |
| EN52 (401S45)          | 7.61 g/cc x (16.38706 x Volume) |
| EN24 (817M40)          | 7.84 g/cc x (16.38706 x Volume) |
| 1.3343                 | 8.10 g/cc x (16.38706 x Volume) |
| 316S11                 |                                 |
| 6082                   | 2.71 g/cc x (16.38706 x Volume) |

### Hardness

| Material's (Valve Steels & Tips)               | Rockwell 'C' Scale | Vicker's '30'        |
|------------------------------------------------|--------------------|----------------------|
| 214N (349S52)                                  | 30 HRc             | 318 Vicker's         |
| 1.4882                                         | 30 HRc             | 385 Vicker's         |
| 352S52                                         |                    |                      |
| EN52 (401S45)                                  | 25 - 31 HRc        | 437 - 395 Vicker's   |
| EN59 (443S65)                                  | 28 - 36 HRc        | 283 - 353.5 Vicker's |
| EN54A (331S42)                                 |                    |                      |
| EN24 (817M40)                                  | 22 - 30 HRc        | 248 - 302 Vicker's   |
| 1.3343                                         | 63 - 66 HRc        | Vicker's             |
| Nimonic (80A)                                  | 32 HRc             | Vicker's             |
| 316S11                                         |                    |                      |
| Armored Seats - Cobalt based deposit - Grade 6 | 38 - 42 HRc        | 371 - 412.5 Vicker's |
| Tips - Cobalt based deposit - Grade 12         | 46 - 50 HRc        | Vicker's             |
| EN24 (welded tips)                             | 52 - 54 HRc        | 541 - 576 Vicker's   |
| EN31 (welded tips)                             | Approx. 64 HRc     | Vicker's             |

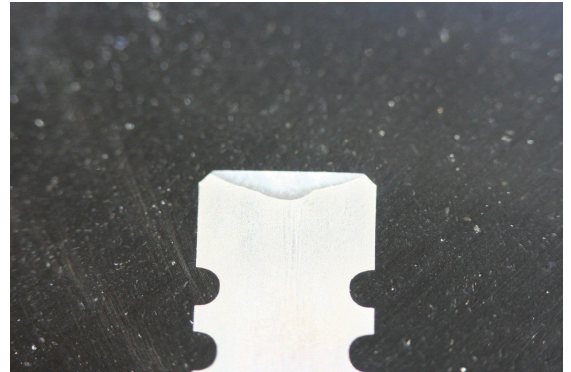
# Surface Treatments

Various treatments are available to enhance the life and performance of your valves, these include the following:

## Hard Tips - Cobalt based deposit - Grade 12

Process for placing a Cobalt based deposit - Grade 12 on an Austenitic Stainless Steel Valve.

1. The valve is ground to finished length +0.001"
2. Using a special profiled solid carbide drill, we drill the tip of the valve until the outer edge of the countersunk hole is at the +0.005" on finished stem diameter.
3. Then using an Induction hardening machine with a vibratory depositing system, we heat the valve up in various stages to keep the right conditions to stop cross contamination during heating.
4. Cobalt based deposit - Grade 12 Powder with a flux additive is deposited into the countersunk hole and meted @1060 degrees C.
5. The valve is now ground to finished length and checked for porosity and hardenss.



## Friction Welded Hard Tip

Process for placing a Friction Welded Hard tip on an Austenitic Stainless Steel Valve.

1. This operation is done at the forging stage of production.
2. The length of the forging is ground to allow for the correct amount of burn-off to ensure the weld position is in the correct position relative to the collet groove.
3. At a later stage during the production cycle the friction welded tip will be hardened using a induction hardening method depending on the relevant material used for the tip.
4. The valve is now ground to finished length and checked for hardness.



## Surface Treatments - continued -

### Diamond like Carbon DLC (Process ?)

This is a Plasma Assisted Chemical Vapour Deposition process (PACVD) which gives a hard layer of 4500 Hk over the complete valve of 3 - 5 microns in depth, the anti-friction qualities are greatly improved as the coefficient of friction ( $\text{Al}_2\text{O}_3$ ) is 0.1, this process is applied at a relatively low temperature of between 200-300 Deg. C. This process is applied after the valve has been Plasma Nitrided, the plasma process gives the valve a substrate that is sufficient to give the DLC coating enough strength to be able to withstand the high contact stresses, and an increase in wear life.

### Pulsed Plasma Nitriding (Process 6 or 7)

Valves for internal combustion engines must have high resistance to thermal stress caused by frequent temperature changes. They must remain ductile but acquire good anti-friction properties to reduce wear in the area of the valve guide. The valve seat must be able to resist the corrosive effects of hot exhaust gases from the engine.

Pulsed Plasma Nitriding (Furnace supplied by Eltropuls) improves the resistance to wear and the anti-friction qualities by increasing the surface hardness along the valve stem, while retaining the inherent corrosion resistance of the material at the valve seat. Pulsed Plasma Nitriding allows high temperature metallurgical reactions to occur at low work surface temperatures, plasma is produced by applying high voltage through a low pressure gas (a mixture of hydrogen and nitrogen) causing it to ionise, using this high energy (but thermally low temperature), plasma will diffuse nitrogen into the surface of the valve.

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Some of the advantages of Pulsed Plasma Nitriding are:

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1. This process is applied at low temperature so it does not affect the original core properties of the substrate material.
2. The nitride layer is more uniform and there is less deviation from mean values, when compared to salt bath or gas nitriding.
3. The anti-friction qualities between the valve stem and the valve guide have been substantially improved.
4. Plasma Nitrided surfaces offer better protection against adhesive and abrasive wear
5. Due to the low temperature process the dimensional stability of the valve is improved.
6. Valves can be masked to allow specific parts to be treated
7. Using this process it is possible to allow other treatments to be applied to further enhance the properties of the valve

By using this process it is also possible to produce a case structure without an Iron Nitride compound (White) layer and this allows the deposition of a subsequent surface coating onto the nitrided surface, to produce a multi layer coating.

eg:

TiAlCrYN (PVD Coating) and DLC - (PACVD Coating)

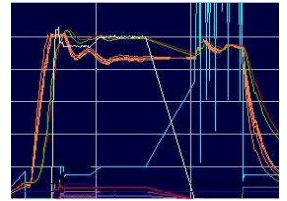


# Surface Treatments - continued -

## Pulsed Plasma Nitriding (Process 113) - continued -

The basic procedure for Pulsed Plasma Nitriding valves are as follows

The valves are washed to remove any traces of oil and machining residues, they are then placed inside the vacuum chamber in a manner that will permit the plasma to gain access to all of its important surfaces. The furnace is then closed, the atmosphere in the chamber is evacuated to give a vacuum. A number of purges and evacuations of the furnace atmosphere are made to ensure that there is no residual air inside the chamber. A voltage is then applied with a controlled gas mixture to produce a plasma. This plasma is first used to sputter cleaned and remove any passive layers on the surface. During these stages the furnace load is heated by both the furnace wall heaters and the plasma until the nitriding temperature is reached at which stage the load is held for a specific amount of time to allow the plasma to produce required nitride. At the end of the nitriding cycle the valves are then cooled down in a vacuum giving a slight grey appearance on the nitrided areas of the valve.



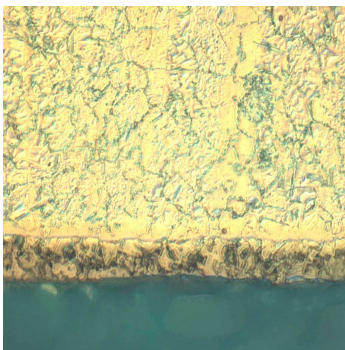
Example of Process Procedure:

1. Initial heating
2. Sputter Cleaning
3. Nitriding
4. Cool down cycle

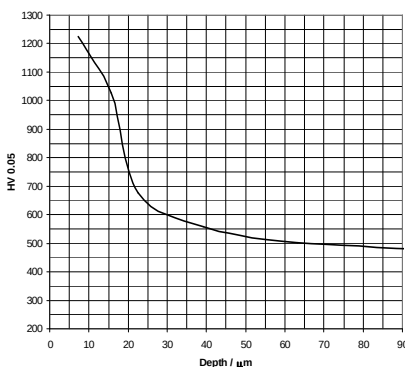
The table below shows the case depth and surface hardness achieved on different valve steels from pulsed plasma.

| Material's (Valve Steels ) | Minimum Surface Hardness (@50 grams load) | Minimum Case Depth microns |
|----------------------------|-------------------------------------------|----------------------------|
| 214N (349S52)              | 1,000 HV0.10                              | 5 microns                  |
| 1.4882                     | 1,000 HV0.10                              | 5 microns                  |
| EN52 (401S45)              | 1,000 HV0.10                              | 10 microns                 |
| EN24 (817M40)              | 600 HV0.10                                | 10 microns                 |
| Nimonic (80A)              | 700 HV0.10                                | 5 microns                  |

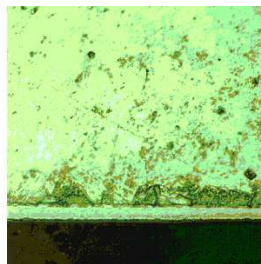
Micrograph of 214N



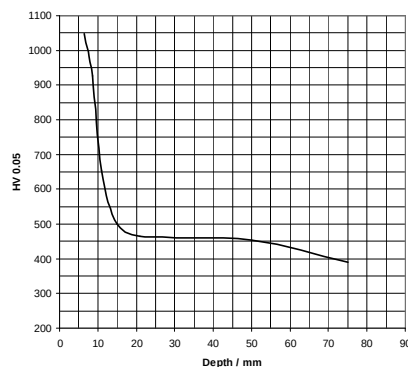
Microhardness Profile - 214N Valve



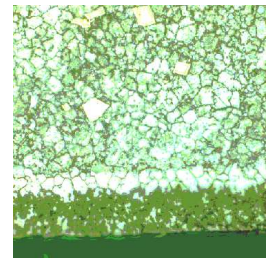
Micrograph of Nimonic 80A



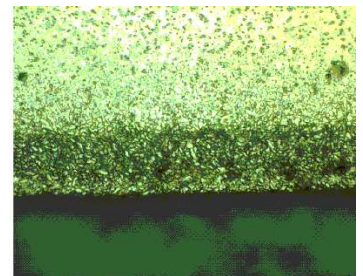
Microhardness Profile - 1.4882 Valve



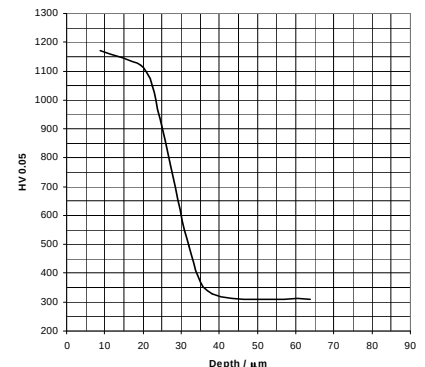
Micrograph of 1.4882



Micrograph of EN52



Microhardness Profile - EN 52 Valve



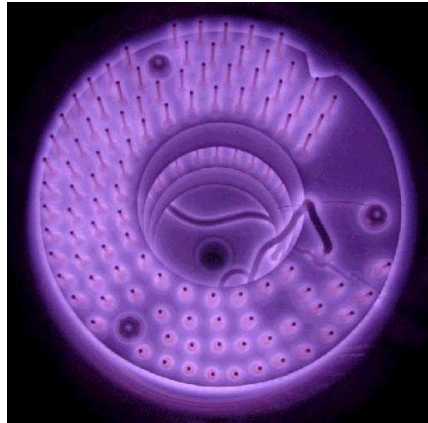
# Surface Treatments - continued -

## Pulsed Plasma Nitriding (Process 113) - continued -

Sample Valve (Pulsed Plasma Nitrided)



Picture through viewing window of 214N valves being Pulsed Plasma Nitrided



Selection of Valves (Pulsed Plasma Nitrided)



**Tufftride** (AB1 or TF1) (The process used depends upon the specification of the valve)

Gives a hard layer of between 72 to 74 Rockwell 'C' over the complete valve of between 10-20 microns in depth, and gives excellent wear properties in a cast iron or bronze guide with the added benefit of stress relieving the valve. This type of treatment gives a black mottled finish all over the valve.

### Tufftride Process

#### TF1

1. De-Grease
2. Process in air circulated furnace @350/250 Deg's C.
3. Process in (TF1) for 40 Min. @ 600 Deg's C
4. Quench in Oil
5. Wash components in hot water then warm water
6. Oil components

#### AB1

1. De-Grease
2. Process in air circulated furnace @350/250 Deg's C.
3. Process in (TF1) for 40 Min. @600 Deg's C
4. Process in salt bath (AB1) @380 Deg's C
5. Quench in cold water
6. Wash components in hot water then, warm water
7. Oil components

## Armored Seats using a Cobalt based deposit - Grade 6s (see Unleaded Seat Section)

A Cobalt based deposit - Grade 6 is placed on the exhaust valve seat face which enhances the seat hardness (Rockwell'C' of between 38 to 42 HRC) which enables it to be used with unleaded fuel or highly stressed engines e.g.: turboed, supercharged or engines that are generally hard on valve seats.

## Sodium Filled Exhaust Valves

Hole 60%-65% filled with Sodium,

three types of specifications:

1. One piece, drilled from the head then plugged
2. Two piece, drilled from the stem then friction welded
3. Two piece, drilled from the stem then swaged closed, then friction welded

## Surface Treatments - continued -

### Shot Peening

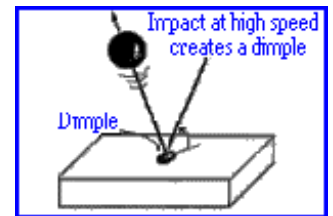
Shot peening is a cold working process in which the surface of a part is bombarded with small spherical media called shot. Each piece of shot striking the material acts as a tiny peening hammer, imparting to the surface a small indentation or dimple. In order for the dimple to be created, the surface fibers of the material must be yielded in tension. Below the surface, the fibers try to restore the surface to its original shape, thereby producing below the dimple, a hemisphere of cold-worked material highly stressed in compression.



Overlapping dimples develop a uniform layer of residual compressive stress in the metal. It is well known that cracks will not initiate or propagate in a compressively stressed zone. Since nearly all fatigue and stress corrosion failures originate at the surface of a part, compressive stresses induced by shot peening provide considerable increases in part life. The maximum compressive residual stress produced at or

under the surface of a part by shot peening is at least as great as one half the yield strength of the material being peened. Many materials will also increase in surface hardness due to the cold working effect of shot peening.

Benefits obtained by shot peening are the result of the effect of the compressive stress and the cold working induced. Compressive stresses are beneficial in increasing resistance to fatigue failures, corrosion fatigue, stress corrosion cracking, hydrogen assisted cracking, fretting, galling and erosion caused by cavitation. Benefits obtained due to cold working include work hardening, intergranular corrosion resistance, surface texturing, closing of porosity and testing the bond of coatings. Both compressive stresses and cold working effects are used in the application of shot peening in forming metal parts.



### Hard Chrome Plating

Gives the stem added durability by depositing chrome on the stem to guide area of the valve of between 32 - 72 microns in thickness, this gives good compatibility if the valve is made in 214N (Stainless) and is to be used in a cast iron guides. This type of treatment is only on the valve stem

### Surface Treatments (Thickness & Hardness)

| Surface Treatment       | Hardness Rockwell 'C' | Hardness Vicker's '30' | Thickness 0.000" (Tenth's)        | Thickness microns |
|-------------------------|-----------------------|------------------------|-----------------------------------|-------------------|
| Hard Chrome Flash       | 52-54 HRC             | 544 - 577 Vicker's     | 12 - 3 tenth's (0.00012 - 0.0003) | 32 - 72 micron's  |
| Tufftride AB1           | 70-74 HRC             |                        | 4 - 8 tenth's (0.0004 - 0.0008)   | 10 - 20 micron's  |
| Tufftride TF1           | 70-74 HRC             |                        | 4 - 8 tenth's (0.0004 - 0.0008)   | 10 - 20 micron's  |
| Pulsed Plasma Nitriding | See Table             | See Table              | See Table                         | See Table         |

Note: 25 micron's = 0.001"

Hard Chrome Flash - Nickel layer gives corrosion protection,

# Cobalt based deposit - Grade 6 - Unleaded Use -

## Armored Seat using a Cobalt based deposit - Grade 6

The whole unleaded question regarding valves is a bit tricky to explain. To begin with certain 'older style' engines can run perfectly satisfactorily on plain 214N material, due to the fact that they are not a modern day 'lean' burn, high revving engines, expected to do modern day mileage and service intervals.

Unfortunately every engine is different. What we have found is that if the cylinder heads have had modern day 'unleaded' hardened seat inserts fitted the seat insert will most probably be too hard for the valve which could excessively wear the valve seat. In this particular case we would recommend a Armored seated exhaust valve.

For racing use unless the engine is a very heavily loaded engine or has forced induction you could usually get away with 214N or 1.4882 material as the valve will not be in service as long as a standard road going valve.

As a rule of thumb any exhaust valve running on modern day fuels should NOT be magnetic, if so, it is a martensitic (magnetic) steel which nowadays is used as inlet valve material. 214N which is an austenitic (non magnetic) stainless steel developed in the 60's and designed to run on leaded fuel. Some older style engines pre 60's used EN54 (non magnetic) steel some with a Cobalt based deposit on the seat or EN59 / EN52 both of which are magnetic materials. Any of these materials would not be as good as a plain 214N exhaust valve. The addition of Armored seat has been implemented due to the demise of leaded fuel leading to excessive seat wear.

The other thing to note is that 214N (austenitic stainless steel) is not compatible to run in cast iron guides without a surface treatment on the stem e.g.: plasma nitride, chrome or tufftride, where EN52 or inlet (magnetic) material without a treatment is acceptable. Nimonic 80A is also not compatible to run with cast iron guides without a surface treatment on the stem e.g.: plasma nitride or chrome, but is acceptable to use unleaded fuel without a Armored seat.

The basic procedure for a depositing a Armored seat on a forging is as follows:



1. Forge a forging as per normal procedure

2. Traking of forging (to be able to deposit a Cobalt based alloy - Grade 6)



3. Welding of the Cobol deposit on the forging

4. Coining of forging (drives the Cobalt deposit in to the base material) and removes any porosity in the Cobalt layer.



5. Section sample forging to determine correct position of the Cobalt deposit

# Valve Steel

Various steels are available, these include the following:

## **EN52**

For many years the standard exhaust valve steel was EN52, this steel was first introduced over 70 - 75 years ago. But since then improved engine design including increased compression and higher operating temperatures, and improved fuels with an increased octane rating and addition of tetra-ethyl-lead have lead to an increasing tendency to prematurely burnout the valve. This steel is classed as “semi” corrosion resistant as they are attacked by Chlorine and Sulphur compounds. As a result this material is no longer considered suitable for exhaust valves, although it is still perfectly satisfactory for inlet valves.

## **EN54 ,KE965 & Jessops G2** *(No longer available)*

Developed to replace EN52 as an exhaust grade steel, this steel possesses excellent creep strength and impact values at high temperature, and has good scaling and corrosion resistance, except in the presence of sulphur, and its resistance to oxidation extends to temperatures above 900 Deg. C. EN54A was expensive to manufacture (in its time) due to the high Nickel content so a new material was developed which was EN59.

## **EN59** *(No longer available)*

This material had a lower thermal expansion rate and good heat conductivity properties which gives much better resistance to high temperature scaling. This steel is resistant to Chlorine compounds but not Sulphur. It is suitable for use where resistance to high octane rated fuels and oils containing tetra-ethyl-lead.

## **214N**

About 1960 a new steel, 214N was developed. This steel retains its hardness even up to temperatures of 800 Deg. C and possesses excellent rupture strength under high temperature conditions combined with good creep and impact values, The high Chromium content gives good scaling resistance, and has greater corrosion resistance against Chlorine although is still not immune to sulphurous attack.

## **1.4882**

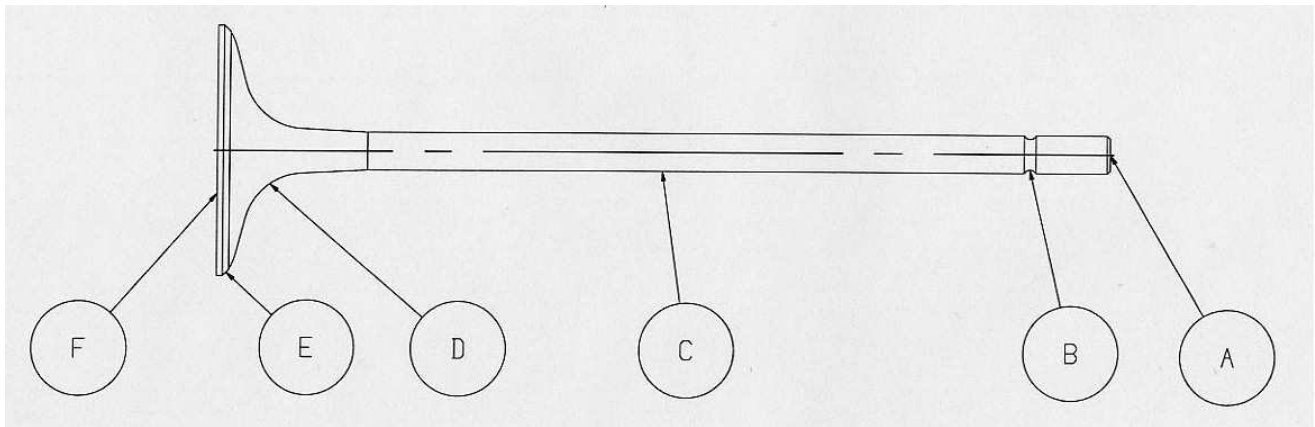
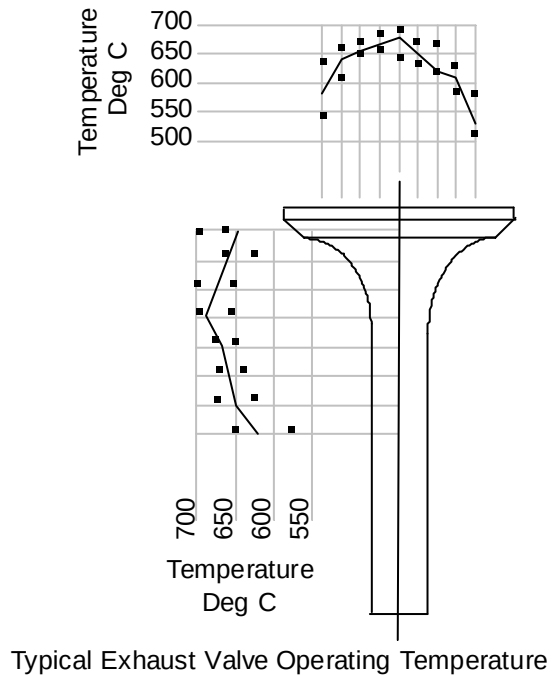
This material has the same properties as 214N (349S52) but with addition of Ta (Tantalum), Nb (Niobium) and W (Tungsten). This gives it greater elongational properties, improved tensile, yield and creep strength. Note: This material is available in stem sizes of (7.44mm - 9/32") or less.

## **Nimonic 80A**

Nimonic 80A has an increased operating temperature over 214N and higher corrosion resistance. Note: Nimonic has an undesirable operating range of between 750-775 Deg. C where it can suffer corrosion (top end of sulphur corrosion overlapping into the bottom end of the oxidation corrosion)

# General Information

Heat flow is through the Back-of-Head (piston side) by radiation during combustion and by conduction through the Back-of-Head, Seat and Stem during the exhaust stroke. Valves pass 75 % of their heat through the valve seat to the seat insert and 25 % from the valve stem to the valve guide.



Typical Requirements for Valves in High-performance Engines

## **A. Valve Tip**

Tribological contact pressures (up to 2000 Mpa), at temperatures of 150 Deg. C. (Max.)

## **B. Collet Groove**

Low wear, at temperatures of 150 Deg. C.

## **C. Valve Stem**

Wear resistance in contact with valve guides, at temperatures ranging from 150 to 300 Deg. C.

## **D. Underhead Area (Stem/Neck)**

Sufficient fatigue strength at temperatures ranging from (Inlet 600 Deg. C.) / (Exhaust 850-950 Deg. C.) and in an oxidizing/corrosive environment.

## **E. Valve Seat**

Wear resistance in contact with valve seats at high surface pressings, at temperatures ranging from (Inlet 400 Deg. C.) / (Exhaust 700 Deg. C.) and in an oxidizing/corrosive environment.

**F. Back of Head -** Resistance against an oxidizing/corrosive environment at temperatures ranging from (Inlet 600 Deg. C.) / (Exhaust 850-950 Deg. C.).



G&S VALVES LTD 

DRAWING No.

REF MANUFACTURING STANDARD

GSSD1 (UNDERCUT VALVE)

TURNED H/D

A $\pm$ 0.002  $\phi$  0.003 A  $\phi$  0.003 AP $\pm$ 0.0025 0.0005 P

ISSUE No. 1

MATERIAL

HEAD/STEM JOIN

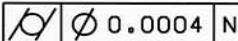
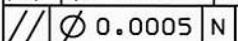
DATE 05/09/94

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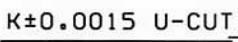
CHECKED BY

ALL DIMENSIONS IN INCHS

MACHINE ALL OVER

GRIND H/D  
A $\pm$ 0.001  $\phi$  0.001 A  
  $\phi$  0.001 AB $\pm$ 0.002E $\pm$ 0.002 SEAT GAUGEG $\pm$ 0.002 U/HEAD GAUGEW $\pm$ 1°J $\pm$ 0.002M $\pm$ 0.002N $\pm$ 0.0005  $\phi$  0.0004 N  
  $\phi$  0.0005 NQ $\pm$ 0.001S $\pm$ 0.003 C/LT $\pm$ 0.005

20°

R $\pm$ 0.001  $\phi$  0.0015 RK $\pm$ 0.0015 U-CUT  
  $\phi$  0.0015 KU $\pm$ 2°30'H $\pm$ 0°30'C $\pm$ 0°15'  $\phi$  0.0005 C

A (SEE NOTE)

D SEAT GAUGE

F U/HEAD GAUGE

L $\pm$ 0.0025

ALL TOLERANCES AS DRAWING UNLESS OTHERWISE STATED

 PARALLELISM CONCENTRICITY CYLINDRICITY SQUARENESS RUN OUT SURFACE FINISH C.L.A.

# General Valve Failures

## Fault Detection

There are many possible fundamental causes of valve failure and it is the purpose of this site to examine these and trace some of the more common failures which can be attributed to operating conditions beyond the control of G&S Valves.

### Head Fractures, Breakage's and Serious Distortion

A  
of

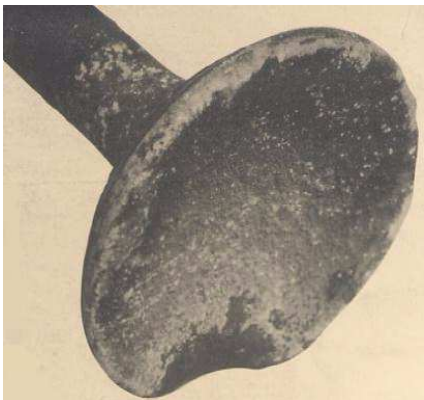


**Effect:**

piece broken away from the valve head roughly in the shape of the chord a circle.

**Cause:**

Very high cylinder pressure and valve temperatures; incorrect valve material; etc. This problem is nearly always confined to exhaust valves.



**Effect:**

Concavity or tuliping of the back of the valve head (piston side)

**Cause:**

Very high cylinder pressures and valve temperatures incorrect valve material.

A



**Effect:**

piece broken away from the valve head roughly segmental in shape, or a radial rim crack propagating inwards.

**Cause:**

Excessive valve temperature together with unequal cooling or cyclic engine loading.

**Example:**

Exhaust gas leaks past the valve seat, causing it to expand into an oval shape, this creates Hoop Stresses in the valve head. After a few cycles of uneven expansion and contraction stress cracks form at the outer edge of the seat, these cracks progress inwards towards the center of valve until they are approx. 1/4" inch long then turn 90 degrees and grow around the valve head, when two cracks meet a piece of the seat breaks off.

the

## General Valve Failures – *continued* -

### Valve Seat & Face Burning, Pitting, Guttering and Corrosion



**Effect:**

Valve burnt out locally in a deep channel or gutter.

**Cause:**

Poor seating due to cold sticking; lack of tappet clearance; excessive carbon buildup; misalignment; worn valve guides; pre-ignition; etc.



**Effect:**

Wide areas of valve face burnt and blowing but no guttering.

**Cause:**

Poor valve seating in affected areas; worn guides; excess material removed from and during previous re-facing operations.



**Effect:**

Badly pitted valve and valve seat faces, discovered on early overhaul due to power loss or a burn out.

**Cause:**

Excessive oil consumption, incorrect mixture setting producing a high level of solid particles or long periods low power cold running.



of



**Effect:**

Exhaust valve underhead or back of head surface corrosion.

**Cause:**

Excessive overload and overheating or incorrect fuel.

## General Valve Failures – *continued* -

### Valve Seat & Face Burning, Pitting, Guttering and Corrosion (*continued*)

A



**Effect:**

hole burnt through the back of head in the underhead radius, just behind the seating face.

**Cause:**

This is another form of the radial rim crack (Head Fractures) or thermal fatigue, burning through beyond the hard seat face.

# General Valve Failures – continued -

## Mechanical

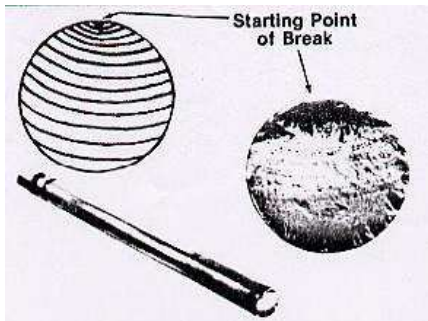
**Effect:**

Valve head to stem breakage in the region of the junction of the underhead radius with the stem.

**Cause:**

Excessive cyclic stem stresses brought about by one or more of the following, valve bounce due to overspeed or weak valve springs, seating velocity too high due to excessive tappet clearance or loss of valve retainer. Piston to valve collision due to overspeed or incorrectly set valve timing or sticking.

### Example's of breakages

**Effect:**

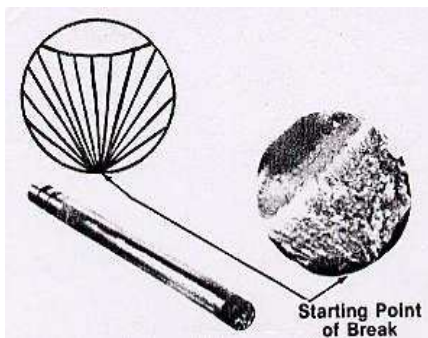
Fatigue break.

**Cause:**

This is fatigue type failure caused by a gradual breakdown of the material due to excessive cyclic stresses, high cylinder pressure and excessive valve temperature.

**Example:**

A fatigue break normally shows lines of progression (see picture).

**Effect:**

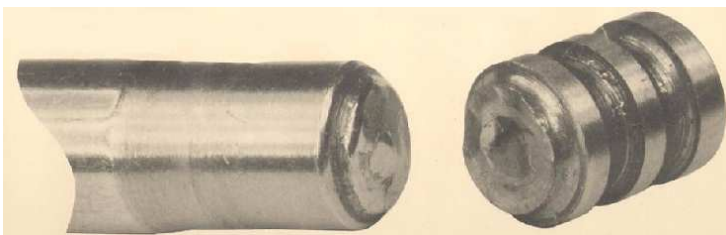
Impact break.

**Cause:**

This is a impact type failure (mechanical breakage of the valve).

**Example:**

A impact break normally shows radial lines (see picture).

**Effect:**

Valve stem breakage through collet groove.

**Cause:**

This type of valve is usually hardened through the cotter grooves and is susceptible to failure due to overspeeding or valve bounce.

## General Valve Failures – *continued* -

### Mechanical (*continued*)

To



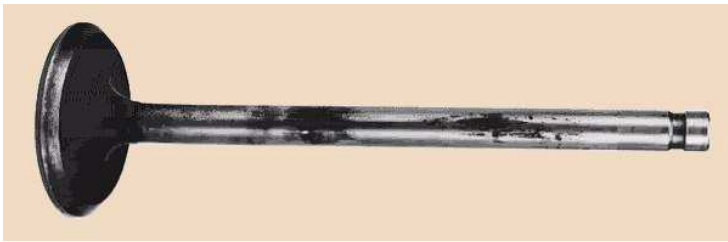
**Effect:**

Excessive valve stem and guide wear.

**Cause:**

much valve stem to guide clearance; poor stem lubrication; poor stem to guide alignment.

A



**Effect:**

Valve stem sticking or seizing.

**Cause:**

lack of lubrication; not enough stem to guide clearance; bent valve stem; carbon build up at the bottom of the valve stem, incompatible valve to guide material.



**Effect:**

Exhaust valve seat wear.

**Cause:**

Incorrect fuel; valve seat misalignment; weak valve springs worn guides.

# Valve Retainers

G&S Valves is now able to produce a wide range of valve retainers to the same high standards as the valves we manufacture. From 'one off' prototypes, for engine development, up to larger batch sizes. We can change the existing collet and manufacture a 'new' design retainer arrangement to give a better taper lock on the valve assembly to enable it to withstand the new breed of high RPM engines.

Various materials are available, these include the following:

## **EN24**

EN24 is a nickel chromium molybdenum steel recognised for its high tensile strength and toughness.

## **6082 T6 Alloy**

6082 Alloy is a high strength alloy with good toughness and corrosion resistance.

## **7075 T6 Alloy**

7075 Alloy is used in the aerospace industry for highly stressed components. Characteristic properties of this material are a very high fatigue strength.

## **6Al-4V (Grade 5) Titanium**

Titanium 6Al-4V is a high-strength, alpha-beta alloy which is fully heat-treatable and is the most versatile of the titanium industry. Titanium is extensively used in the aerospace industry and increasingly used in the automotive industry in applications where weight or space are factors or corrosion is a problem.

## **AMS 6514D Maraging**

Maraging AMD6514D belongs to the family of iron-based alloys, and is strengthened by a process of martensitic transformation followed by ageing. This material works well where ultra-high strength is required and has good dimensional stability. Due to the fact that this material has such good mechanical properties and is nearly the same volumetric weight as steel it is therefore possible to manufacture a small/thinner sectioned retainer (ie: similar weight to a retainer manufacture from titanium) but with the benefits of steel or where titanium is banned.

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Some of the desirable properties of this material are:

1. Ultra-high strength.
2. Minimum distortion.
3. Superior fracture toughness compared to quenched and tempered steel of similar strength.
4. Low carbon content, which precludes decarburization problems.

Example of various types of retainers



# Mechanical Properties

## Tensile Strength, Proof Stress & Creep Strength

| Material          | Tensile Strength<br>(N/sq. mm) | 0.2% Proof Stress<br>(Yield Strength)<br>(N/sq. mm) | Elongation<br>after Fracture<br>(L=5d)^2<br>E % | Creep Strength<br>(after 1000 h)<br>(N/sq. mm) | Hardness               |
|-------------------|--------------------------------|-----------------------------------------------------|-------------------------------------------------|------------------------------------------------|------------------------|
| EN24 - (817M40)   | 980                            | 870                                                 | 13                                              |                                                | 248 - 302 Brinell (HB) |
| 6082 - (T6)       | 340                            | 270                                                 | 11                                              | 200                                            | 95 Brinell (HB)        |
| 7075 - (T6)       | 572                            | 503                                                 | 10                                              | 245                                            | 150 Brinell (HB)       |
| 6Al-4V (Grade 5)  | 900                            | 830                                                 | 10 - 18                                         |                                                | 36 HrC                 |
| AMS 6514 Maraging | 2027                           | 1,999                                               | 11                                              |                                                | 52 HrC                 |

## Thermal Conductivity

| Material          | Thermal<br>Conductivity<br>W/(m.K) | Mean Coefficient of<br>Thermal Expansion<br>10 exp(-6).K(-1) | Melting Point   |
|-------------------|------------------------------------|--------------------------------------------------------------|-----------------|
| EN24 - (817M40)   | 37.7                               |                                                              |                 |
| 6082 - (T6)       | 172                                | 20 Deg C 23.1                                                | 575 - 650 Deg C |
| 7075 - (T6)       | 130                                | 20 Deg C 23.4                                                | 532 - 635 Deg C |
| 6Al-4V (Grade 5)  | 6.7                                |                                                              |                 |
| AMS 6514 Maraging |                                    | 482 Deg C 10.1                                               |                 |

## % Chemical Composition

| Material | C | Si | Mn | Ni | Cr | N | S | P | Cu | Fe | Ti | Al | Mo | O2 | V | H2 | Mg | Zn | Co | Ca | Zr |
|----------|---|----|----|----|----|---|---|---|----|----|----|----|----|----|---|----|----|----|----|----|----|
|----------|---|----|----|----|----|---|---|---|----|----|----|----|----|----|---|----|----|----|----|----|----|

### Wrought Steel (EN Series)

|                  |              |              |              |              |              |  |             |              |  |      |  |  |              |  |  |  |  |  |  |  |  |
|------------------|--------------|--------------|--------------|--------------|--------------|--|-------------|--------------|--|------|--|--|--------------|--|--|--|--|--|--|--|--|
| EN24<br>(817M40) | 0.35<br>0.44 | 0.10<br>0.35 | 0.45<br>0.70 | 1.30<br>1.70 | 1.00<br>1.40 |  | 0.04<br>Max | 0.04<br>Max. |  | Bal. |  |  | 0.20<br>0.35 |  |  |  |  |  |  |  |  |
|------------------|--------------|--------------|--------------|--------------|--------------|--|-------------|--------------|--|------|--|--|--------------|--|--|--|--|--|--|--|--|

### Titanium Alloys

|        |       |  |  |  |  |       |  |  |  |       |      |             |  |      |            |       |  |  |  |  |  |
|--------|-------|--|--|--|--|-------|--|--|--|-------|------|-------------|--|------|------------|-------|--|--|--|--|--|
| 6Al-4V | <0.08 |  |  |  |  | <0.05 |  |  |  | <0.25 | Bal. | 5.5<br>6.76 |  | <0.2 | 3.5<br>4.5 | <0.01 |  |  |  |  |  |
|--------|-------|--|--|--|--|-------|--|--|--|-------|------|-------------|--|------|------------|-------|--|--|--|--|--|

### Aluminum Alloys

|                |  |             |              |  |              |  |  |  |              |      |      |      |  |  |  |  |              |              |  |  |  |
|----------------|--|-------------|--------------|--|--------------|--|--|--|--------------|------|------|------|--|--|--|--|--------------|--------------|--|--|--|
| 6082 -<br>(T6) |  | 7.00<br>1.3 | 0.40<br>1.00 |  | 0.25         |  |  |  | 0.10         | 0.50 | 0.10 | Bal. |  |  |  |  | 0.60<br>1.2  | 0.20         |  |  |  |
| 7075 - (T6)    |  | 0.40        | 0.30         |  | 0.18<br>0.28 |  |  |  | 1.20<br>2.00 | 0.50 | 0.20 | Bal. |  |  |  |  | 2.10<br>2.90 | 5.10<br>6.10 |  |  |  |

### Maraging Steel

|          |      |      |      |          |      |  |      |      |      |      |              |              |              |  |  |  |  |  |              |      |      |
|----------|------|------|------|----------|------|--|------|------|------|------|--------------|--------------|--------------|--|--|--|--|--|--------------|------|------|
| AMS6514D | 0.03 | 0.10 | 0.10 | 18<br>19 | 0.50 |  | 0.01 | 0.01 | 0.50 | Bal. | 0.50<br>0.80 | 0.05<br>0.15 | 4.70<br>5.10 |  |  |  |  |  | 8.00<br>9.50 | 0.05 | 0.03 |
|----------|------|------|------|----------|------|--|------|------|------|------|--------------|--------------|--------------|--|--|--|--|--|--------------|------|------|

C - Carbon    Si - Silicon    Mn - Manganese    Ni - Nickel    Cr - Chromium    N - Nitrogen    S - Sulfur  
P - Phosphorus    Cu - Copper    Fe - Iron    Ti - Titanium    Al - Aluminum    Mo - Molybdenum    O - Oxygen  
V - Vanadium    H - Hydrogen    Mg - Magnesium    Zn - Zinc    Ca - Calcium    Zr - Zirconium

## Volumetric Weight

| Material +/- 0.5 Grams        | Volumetric Weight               |
|-------------------------------|---------------------------------|
| 6Al/4V (Grade 5) – Titanium - | 4.42 g/cc x (16.38706 x Volume) |
| EN24 (817M40)                 | 7.84 g/cc x (16.38706 x Volume) |
| 6082 - (T6)                   | 2.70 g/cc x (16.38706 x Volume) |
| 7075 - (T6)                   | 2.80 g/cc x (16.38706 x Volume) |
| 225XE (Metal Matrix)          | 2.88 g/cc x (16.38706 x Volume) |
| AMS6514D                      | 8.04 g/cc x (16.38706 x Volume) |

# Surface Treatments

Various treatments are available to enhance the life and performance of your retainers, these include the following:

## **Titanium - Plasma Nitriding (Process 1001)**



Pulsed Plasma Nitriding allows high temperature metallurgical reactions to occur at low work surface temperatures. Plasma is produced by applying high voltage through a low pressure gas causing it to ionise, using this high energy (but thermally low temperature), plasma will diffuse nitrogen into the surface of the retainer. This process gives a hard case with a surface hardness of >700 HV0.05 over the exposed surface of between 10-30 microns at 0.050mm over core in depth, incorporated in this nitrided layer is a TiN layer of between 1-3 microns, therefore there is not any adhesion problems possibly associated with TiN as a hard coating.

The basic procedure for Pulsed Plasma Nitriding retainers are as follows:

The retainers are washed to remove any traces of oil and machining residues, they are then placed inside the vacuum chamber in a manner that will permit the plasma to gain access to all of its important surfaces. The furnace is then closed, the atmosphere in the chamber is evacuated to give a vacuum. A number of purges and evacuations of the furnace atmosphere are made to ensure that there is no residual air inside the chamber. A voltage is then applied with a controlled gas mixture to produce a plasma. This plasma is first used to sputter cleaned and remove the passive layer on the surface of the titanium. During these stages the furnace load is heated by both the furnace wall heaters and the plasma until the nitriding temperature is reached at which stage the load is held for a specific amount of time to allow the plasma to produce the required nitride case depth. At the end of the nitriding cycle the retainers are then cooled down in a vacuum. This type of treatment produces a characteristic gold TiN color in the nitrided areas on the retainer.

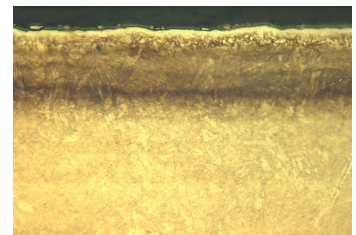
Example of Process Procedure:

1. Initial heating
2. Sputter Cleaning
3. Nitriding
4. Cool down cycle

## **Maraging Steel - Age & Plasma Nitriding (Process 11)**

Pulsed Plasma Nitriding allows high temperature metallurgical reactions to occur at low work surface temperatures. Plasma is produced by applying high voltage through a low pressure gas causing it to ionise, using this high energy (but thermally low temperature), plasma will diffuse nitrogen into the surface of the retainer. This process gives a hard case with a surface hardness of >900 HV0.05 over the exposed surface of 0.10mm over core in depth.

Typical micrograph showing case (500x)



The basic procedure for Pulsed Plasma Nitriding retainers are as follows:

The retainers are washed to remove any traces of oil and machining residues, they are then placed inside the vacuum chamber in a manner that will permit the plasma to gain access to all of its important surfaces. The furnace is then closed, the atmosphere in the chamber is evacuated to give a vacuum. A number of purges and evacuations of the furnace atmosphere are made to ensure that there is no residual air inside the chamber. A voltage is then applied with a controlled gas mixture to produce a plasma. This plasma is first used to sputter cleaned and remove any passive layers on the surface of the maraging. During these stages the furnace load is heated by both the furnace wall heaters and the plasma until the ageing temperature is reached, at which stage the load is held for a specific amount of time to allow the required aged properties to be achieved. After the ageing process, the furnace then proceeds to the nitriding temperature and is held for a specific amount of time to allow the plasma to produce the required nitride case.

Note: Maraging shrinks per liner inch on aging and grows per surface at a rate of approx 3/4 of diffusion zone

## Surface Treatments – continued -

### **Maraging Steel - Age & Plasma Nitriding (Process 11) – continued -**

At the end of the nitriding cycle the retainers are then cooled down in a vacuum. This type of treatment produces a slightly grey appearance in the nitrided areas on the retainer.

Example of Process Procedure:

1. Initial heating
2. Sputter Cleaning
3. Aging
4. Nitriding
5. Cool down cycle

### **EN24 - Plasma Nitriding (Process 12)**

Pulsed Plasma Nitriding allows high temperature metallurgical reactions to occur at low work surface temperatures. Plasma is produced by applying high voltage through a low pressure gas causing it to ionise, using this high energy (but thermally low temperature), plasma will diffuse nitrogen into the surface of the retainer.

The basic procedure for Pulsed Plasma Nitriding retainers are as follows:

The retainers are washed to remove any traces of oil and machining residues, they are then placed inside the vacuum chamber in a manner that will permit the plasma to gain access to all of its important surfaces. The furnace is then closed, the atmosphere in the chamber is evacuated to give a vacuum. A number of purges and evacuations of the furnace atmosphere are made to ensure that there is not residual air inside the chamber. A voltage is then applied with a controlled gas mixture to produce a plasma. This plasma is first used to sputter cleaned and remove any passive layers on the surface. During these stages the furnace load is heated by both the furnace wall heaters and the plasma until the nitriding temperature is reached at which stage the load is held for a specific amount of time to allow the plasma to produce the required nitride case. At the end of the nitriding cycle the retainers are then cooled down in a vacuum giving a slightly grey appearance in the nitrided areas on the retainer. This process gives a hard case with a surface hardness of >600 HV0.05 over the exposed surface of 0.10mm over core in depth.



Example of Process Procedure:

1. Initial heating
2. Sputter Cleaning
3. Nitriding
4. Cool down cycle

### **Alloy - Hard Anodizing**

Sub-Contract Process

# Contact Information

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## Address

Alder Works,  
Catteshall Lane,  
Godalming,  
Surrey,  
England.  
GU7 1JS

## Sales

Contact: Sue Styles  
Andrew Grenside

E-Mail: [GSValves@aol.com](mailto:GSValves@aol.com)

Phone : +44 (0) 1483 415444  
Fax : +44 (0) 1483 426891



## Technical

Contact: Andrew Grenside

E-Mail: [GSValves@aol.com](mailto:GSValves@aol.com)

Phone : +44 (0) 1483 415444  
Fax : +44 (0) 1483 426891

## Accounts

Contact: Amelia Reids

E-Mail: [GSValvesacc@aol.com](mailto:GSValvesacc@aol.com)

Phone : +44 (0) 1483 425907  
Fax : +44 (0) 1483 426891

## Directions

To get to G&S Valves Ltd.

From M25 (Junction 10, A3),  
travel south towards Portsmouth (approx 11 miles),  
past Guildford,  
exit at Compton (B3000),  
through Compton to a mini roundabout (approx. 2 miles),  
turn right (A3100) to Godalming,  
turn left (approx. 1-1.5 miles) into Catteshall Road,  
turn left at mini roundabout into Catteshall Lane (approx. 1 mile),  
G&S on the right just around the corner.