RISK BASED PUMP-SEAL SELECTION GUIDELINE COMPLEMENTING ISO 21049/API 682

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ABSTRACT

The API 682 (2004) seal "Arrangement" selection logic is a questionnaire posing questions about customer experience, local regulations and seal leakages requiring a vendor, customer iterative dialogue. The proposed selection procedure overcomes this shortfall using the internationally recognized Globally Harmonized System Hazard codes (2003) and safety information within the pumped fluid Material Safety Data Sheet (MSDS). The major advantage of this approach is that an MSDS includes local requirements regarding personnel exposure and environmental limitations, and is in a constant state of revision as local rules and regulations change or as the hazard codes of substances change. This allows the selection procedure to remain valid regardless of these revisions.

The intent of this paper is to encourage users and the industry generally to adopt this or a similar approach leading to a consistent, safety-orientated selection of seals with a clear, repeatable decision logic.

INTRODUCTION

Although mechanical seals are selected every day by users, contractors, and seal vendors, there is no universally accepted system for choosing between a single seal and a pressurized or unpressurized dual seal. The selection guideline in annex A of ISO 21049/API 682 (Ref 1) includes a flowchart of questions referring to customer experience, local regulations and expected seal leakages that require a vendor-customer iterative dialogue to reach a selection of the seal arrangement. User specifications or seal selection templates often dictate the type, arrangement and category based on a variety of service conditions, but these specifications are often proprietary and consistency between them is somewhat coincidental. Presented here is the TOTAL Refining and Marketing procedure for selecting a mechanical seal arrangement based on internationally established hazard classifications.

ISO 21049/API 682 OVERVIEW

There are four basic parameters defining an ISO 21049/API 682 (2004) pump seal:

- Category
- Type
- Flush plan
- Arrangement

The selection of the category, type and flush plan for a particular application is well covered in Annex A of ISO 21049/API 682.

- Seal category is selected primarily by seal chamber dimensions that are determined by the pump design in which the seal is to be installed.
- Seal type selection is dictated by seal chamber pressures and temperatures leading to different materials, springs or bellows.
- Seal flush plan is chosen as a function of the selected seal arrangement.

Annex A guides the user through the selection of these parameters with clear, simple to use logic diagrams and tables. Users of the ISO 21049/API 682 standard will almost unanimously agree that the selection of seal category, type and flush plan is covered adequately in the standard. In addition, the technical aspects associated with the selection of these seal parameters are well known by most users and seal vendors.

SEAL ARRANGEMENTS

There are three arrangements proposed by ISO 21049/API 682 and they are illustrated in Figure 1:

- Arrangement 1, previously called "single seal"
- Arrangement 2, previously called "tandem" or "dual" or "dual unpressurized"
- Arrangement 3, previously called "double" or "dual pressurized"

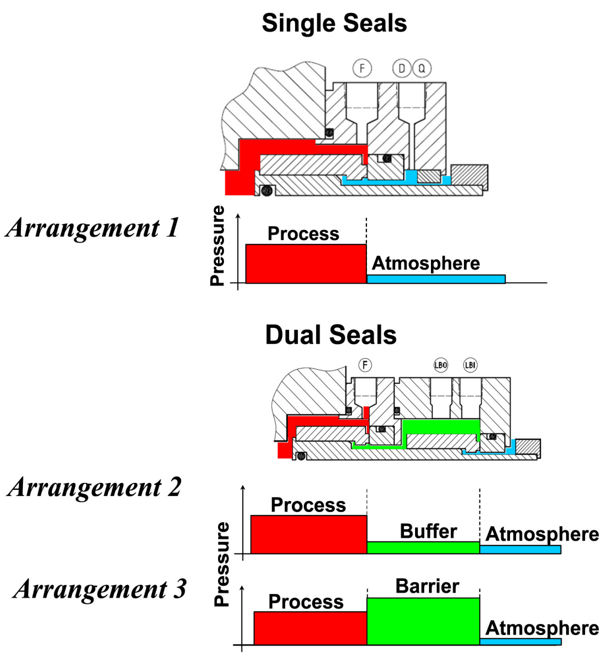

Figure 1 Illustration of Seal Arrangements.

The selection of the seal arrangement in ISO 21049/API 682 is carried out using a flowchart of questions that require the user to have an extremely wide knowledge of subjects varying from local environmental and safety requirements to the normal expected seal leakages of the, as yet, unselected seal. This questionnaire is more complicated than the tables and logic diagrams selecting seal category, type and flush plan, but does assist an informed user.

However, in most cases, seal vendors propose or users dictate the required seal arrangement based on "shared experience" and knowledge between company employees and seal vendors, often based on a simple generic description of the fluid to be sealed. This is one possible explanation why seal requirements vary significantly between users and the choice of seal arrangement can vary between operating facilities in the same company and between companies resulting in a somewhat subjective selection process. Worth noting is that the selection of the seal arrangement has the largest impact on seal leakage and therefore safety, and arguably should strive to be a more transparent, global, objective selection process.

While this author recognizes that in most cases there is more than one technical solution that will comply with user requirements and local regulation on monitoring and leakage limits, the following selection procedure provides a consistent and repeatable seal arrangement selection using primarily the hazard classifications of the fluid according to the internationally recognized United Nations Globally Harmonized System.

THE GLOBALLY HARMONIZED SYSTEM

In 2003, the United Nations adopted the Globally Harmonized System of Classification and Labelling of Chemicals (GHS) (Ref 2). The GHS includes criteria for the classification of health, physical and environmental hazards, as well as specifying what information should be included on labels of hazardous chemicals and in material safety data sheets.

At the end of 2008, which was the original goal, the implementation of GHS into the laws of each of the 67 participating countries, listed on the United Nations Economic Commission for Europe (UNECE) website (Ref 3), varies from being complete in some countries to various promises of completion at a later date. This means that in many countries the GHS hazard classification or "H statement" may not yet be available, in which case the European hazard classification or "R phrase" may be used. The R phrase classification has been in existence since 1967 (Ref 4) and is well known by industrial hygienists throughout the world.

As each country includes the GHS within its legal framework it will include a list of dangerous substances to be used to establish the H statements applicable to a given substance or mixture of substances. Figure 2 is an example showing part of the classification for gasoline from the European list of substances included in the EU Regulation 1272/2008 (Ref 5) that introduced GHS into European law.

Index No	International Chemical Identification	EC No	CAS No	Classification	
				Hazard Class and Category Code(s)	Hazard statement Code(s)
649-378-00-4	Gasoline: Low boiling point naphtha - unspecified [A complex combination of hydrocarbons consisting primarily of paraffins, cycloparrafins, aromatic and olefonic hydrocarbons having carbo, numbers predominantly greater than C3 and boiling in the range of 30 °C to 260 °C (86 °F to 500 °F)]	289-220-8	86290-81-5	Carc. 1B Asp. Tox. 1	H350 H304

Figure 2. Extract from EU Regulation 1272/2008 Substance List.

The European list includes over 8000 substances and the GHS also includes rules for the classification and hence H statements of mixtures of substances to obtain an overall classification according to the concentration of each substance within the mixture.

The H Statement Codes and R Phrases

These two hazard classifications describe a simple code for different types of hazard. The (H)azard statement is the GHS method of classification and the (R)isk phrase is the older European method (Ref 4). The EU started phasing out the R phrase and replacing it by the H statement in December 2008. This process is expected to be complete by 2015. Some examples of H statement codes are given in Table 1.

Table 1. Examples of H Statement Codes.

H224	Extremely flammable liquid and vapour
H226	Flammable liquid and vapour
H330	Fatal if inhaled
H331	Toxic if inhaled
H350	May cause cancer

R phrases range from R 1 to R65 and are very similar to the H statement codes. The equivalents of Table 1 are shown in Table 2 and a conversion table (Ref 6) exists in the EU Regulation 1272/2008. Users of systems such as the National Fire Protection Association (NFPA) (Ref 7) diamond will recognize the principle of these codes.

Table 2. Equivalent R Phrase Codes for Table 1.

R12	Extremely flammable
R10	Flammable
R26	Very toxic by inhalation
R23	Toxic by inhalation
R45	May cause cancer

Each of these hazard codes has a clear and concise definition within the GHS and within the legislative text for each country that adopts the system. Table 3 shows, as an example, the GHS definitions for flammable liquids given by the EU Regulation 1272/2008 (Ref 8). Therefore to be classified as H224—extremely flammable liquid, a liquid must have a flash point <23°C and an initial boiling point ≤35°C.

Table 3. Extract from EU Regulation 1272/2008, Flammable Liquids.

Criteria for flammable liquids

Category	Criteria
1	Flash point < 23 °C and initial boiling point ≤ 35 °C
2	Flash point < 23 °C and initial boiling point > 35 °C
3	Flash point ≥ 23 °C and ≤ 60 °C (1)

(1) For the purpose of this Regulation gas oils, diesel and light heating oils having a flash point between ≥ 55 °C and ≤ 75 °C may be regarded as Category 3.

Label elements for flammable liquids

Classification	Category 1	Category 2	Category 3
GHS Pictograms			
Signal Word	Danger	Danger	Warning
Hazard Statement	H224: Extremely flammable liquid and vapour	H225: Highly flammable liquid and vapour	H226: Flammable liquid and vapour

The definitions for Acute Toxicity H331 and H332 are far more complicated relying on a number of detailed toxicity test results on rats giving LD_{50} (oral and dermal) and LC_{50} (inhalation) values. Anybody wishing to understand more about toxicity definitions and testing should refer to the GHS text ST/SG/AC.10/30 Rev 2 or the EU Regulation 1272/2008.

To obtain the "H statement codes," the purchaser must supply to the vendor a Material Safety Data Sheet (MSDS) for the pumped fluid according to the GHS legislation in the country where the seal will be used. The latest EU Regulation 1272/2008 defines all substances that are considered hazardous according to GHS and includes a conversion table (Ref 6) from R phrases to H statement codes.

THE MATERIAL SAFETY DATA SHEET

The MSDS is a document that is defined in standards such as ANSI Z400.1-2004, OSHA Form 174, European directives and other national standards and is in current use throughout the petroleum and petrochemical industries. Some standards such as ANSI and OSHA do not currently include H statements or R phrases although OSHA is working on the introduction within the near future.

Today all producers of petroleum and petrochemical products worldwide are obliged to supply an MSDS for any finished chemical product that leaves the plant and in some cases intermediate substances and mixtures that do not leave the plant. Therefore these companies already have procedures and expertise in place to create these documents for any intermediate products being pumped that have not already been classified, and their industrial hygienists will already be aware of the arrival of GHS and the H statement and will have been using the R phrase since 1967 for many international products especially those destined for Europe.

Purchasers who do not have such expertise can easily find professional authors of MSDSs, many of whom already work for the large petroleum companies and are also already well-versed in the use of H statements and R phrases within MSDSs. These authors usually have databases and software available to rapidly supply an MSDS for the applicable country giving the necessary information to use this seal selection procedure.

GROUPING H STATEMENT CODES AND R PHRASES

For this selection procedure, all applicable H statement codes and R phrases have been sorted into four groups.

- *Group I* being those R phrases and H statement codes for products that are intrinsically dangerous by their presence, hence requiring the maximum sealing possible.
- *Group II* includes those R phrases and H statement codes that are considered intrinsically dangerous due to their toxicity and put personnel at risk primarily by inhalation. This group requires a treatment of the risk from equipment that, by design or during operation, normally has a small but quantifiable leakage that may cause personnel to be continually exposed to a polluted atmosphere.
- *Group III* covers those R phrases and H statement codes that are potentially dangerous but require a second parameter (e.g., ignition source) for that danger to be realized. Therefore personnel are not in danger simply due to the presence of small quantities of the substance but a real danger occurs if the primary sealing mechanism fails and large quantities of the substance are released. This group therefore requires a treatment (sometimes known as "secondary containment") of the risk due to unplanned excessive leakage.
- *Group IV* includes the remaining R phrases and H statement codes for less hazardous fluids that existing drainage systems within the plants keep from entering the environment.

The grouping of H statement codes and R phrases is made with the following assumptions:

- Seals shall be operated within their design limits.
- Operators shall be equipped with the protective equipment recommended in the MSDS.
- Standard operating practices should include all the precautions on the MSDS.

A simplification of the philosophy behind this grouping is that basically:

- Group I fluids require an Arrangement 3 seal.
- Group II fluids require an arrangement subject to the concentration of hazardous substances within the fluid and the likely concentrations of those substances around the pump seal due to the small but continuous leakage from most seals.
- Group III fluids should require an Arrangement 1 seal but due to the potential hazard in the event of a seal failure, an Arrangement 2 seal is required to limit the leakage caused by the failure of the inner seal. This is primarily a question of containment in the event of failure.
- Group IV fluids require an Arrangement 1 seal since a failure of the seal would not put personnel attending the failure at risk.

Tables 4 and 5 give the group numbers for each H statement and R phrase. The selection procedure selects the seal arrangement based on the Group within which the pumped liquid falls. Because the liquid being considered usually has more than one H statement, each H statement has to be considered to establish the Group to be used.

Table 4. H Statement Group Table.

H Statement	Group		H Statement	Group		H Statement	Group
EUH001	I		H242 [a]	III		H332	IV
EUH006	I		H250	I		H333	IV
EUH014	I		H251	I		H334	III
EUH018	III		H252	I		H335	IV
EUH019	III		H260	III		H336	IV
EUH029	III		H261	III		H340	II
EUH031	III		H270	III		H341	II
EUH032	II		H271	III		H350	II
EUH044	III		H272	III		H350i	II
EUH059	IV		H280	n/a		H351	II
EUH066	IV		H281	n/a		H360D	II
EUH070	IV		H290	n/a		H360Df	II
EUH071	II		H300	III		H360F	II
H200	I		H301	IV		H360FD	II
H201	I		H302	IV		H360Fd	II
H202	I		H303	IV		H361d	III
H203	I		H304	IV		H361f	III
H204	III		H305	IV		H361fd	III
H205	III		H310	II		H362	III
H220	III		H311	IV		H370	II
H221	III		H312	IV		H371	III
H222	III		H313	IV		H372	II
H223	III		H314	III		H373	III
H224	III		H315	IV		H400	IV
H225	III		H316	IV		H401	IV
H226	IV		H317	IV		H402	IV
H227	IV		H318	III		H410	IV
H228	n/a		H319	IV		H411	IV
H240	I		H320	IV		H412	IV
H241	I		H330	II		H413	IV
H242	III		H331	III			

note a) self reacting liquid

Table 5. R Phrase Group Table.

R-Phrase	Group	R-Phrase	Group	R-Phrase	Group
R 1	I	R 30	III	R 48/20/22	III
R 2	III	R 31	III	R 48/21	III
R 3	I	R 32	II	R 48/21/22	III
R 4	I	R 33	III	R 48/22	III
R 5	III	R 34	III	R 48/23	II
R 6	I	R 35	III	R 48/23/24	II
R 7	III	R 36	IV	R 48/23/24/25	II
R 8	III	R 36/37	IV	R 48/23/25	II
R 9	III	R 36/37/38	IV	R 48/24	III
R 10	IV	R 36/38	IV	R 48/24/25	III
R 11	III	R 37	IV	R 48/25	III
R 12	III	R 37/38	IV	R 49 Cat 1	II
R 13	n/a	R 38	IV	R 49 Cat 2	III
R 14	I	R 39	III	R 49 Cat 3	III
R 14/15	I	R 39/23	II	R 50	IV
R 15	III	R 39/23/24	II	R 50/53	IV
R 15/29	II	R 39/23/24/25	II	R 51	IV
R 16	III	R 39/23/25	II	R 51/53	IV
R 17	I	R 39/24	III	R 52	IV
R 18	III	R 39/24/25	III	R 52/53	IV
R 19	III	R 39/25	III	R 53	IV
R 20	IV	R 39/26	II	R 54	IV
R 20/21	IV	R 39/26/27	II	R 55	IV
R 20/21/22	IV	R 39/26/27/28	II	R 56	IV
R 20/22	IV	R 39/26/28	II	R 57	IV
R 21	IV	R 39/27	III	R 58	IV
R 21/22	IV	R 39/27/28	III	R 59	IV
R 22	IV	R 39/28	III	R 60	II
R 23	III	R 40	III	R 61	II
R 23/24	III	R 41	III	R 62	III
R 23/24/25	III	R 42	III	R 63	III
R 23/25	III	R 42/43	III	R 64	III
R 24	IV	R 43	IV	R 65	IV
R 24/25	IV	R 44	III	R 66	IV
R 25	IV	R 45 Cat1	II	R 67	IV
R 26	II	R 45 Cat 2	III	R 68	IV
R 26/27	II	R 45 Cat 3	III	R 68/20	III
R 26/27/28	II	R 46	II	R 68/20/21	III
R 26/28	II	R 47	II	R 68/20/21/22	III
R 27	III	R 48	III	R 68/20/22	III
R 27/28	III	R 48/20	III	R 68/21	IV
R 28	III	R 48/20/21	III	R 68/21/22	IV
R 29	III	R 48/20/21/22	III	R 68/22	IV

Figure 3 shows an example of an MSDS for gasoline. This MSDS classifies gasoline with R phrases because the introduction of H statement codes is so recent that few companies have revised their MSDSs at this time. These R phrases are repeated in Table 6 for clarity.

Safety Data Sheet

Product name : **SP95 / E10** Page : 1/11

SDS n° :38117-33 Version :1.00 Version of :2009-02-26
This sheet supersedes the one dated :2009-02-26

PRODUCT LABELS

LABELLING (standard or EU): Concerned

Symbol(s) :

Symbol(s) : T Toxic F+ Extremely Flammable N Dangerous for the environment.

Contains : Gasoline

R-phrases : R-12 Extremely flammable.
R-45 May cause cancer.
R-46 May cause heritable genetic damage.
R-63 Possible risk of harm to the unborn child.
R-38 Irritating to skin.
R-65 Harmful: may cause lung damage if swallowed.
R-67 Vapours may cause drowsiness and dizziness.
R-51/53 Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

Figure 3. An Example of an Extract from a Typical MSDS for Unleaded Gasoline.

Table 6. R Phrases for this Example of Gasoline.

R Phrase	R12	R45	R46	R63	R38	R65	R67	R51/53

Using the European Regulation 1272/2008 (Ref 6) these R phrases translate to the equivalent H statement codes shown in Table 7.

Table 7. Equivalent H Statement Codes for Table 6.

H Statement	H224	350	340	361d	315	304	336	411

Table 4, the H statement grouping table from the proposed selection procedure, gives the groups shown in Table 8. The group for this example of gasoline would therefore be group II that is the most severe group within Table 4.

Table 8. Groups Given from Table 4.

Group	III	II	II	III	IV	IV	IV	IV

The user enters at the top of the seal arrangement selection logic shown in Figure 4. Starting at the top of the seal selection logic diagram, gasoline has a specific gravity greater than 0.5, is not Group I, has a viscosity less than 700 cSt, and for this example is considered below 250°C and not self igniting. Therefore the Group II selection box directs the user to the Group II Seal Arrangement Selection Chart shown in Figure 5.

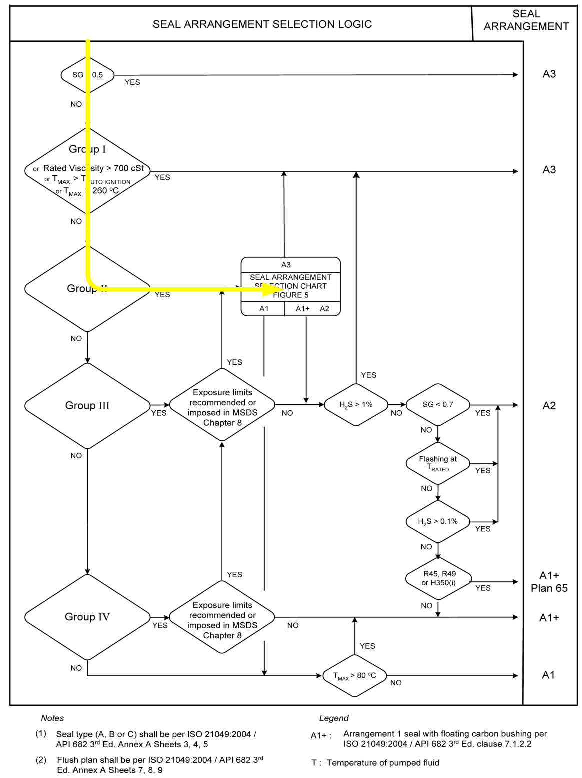

Figure 4. Seal Arrangement Selection Logic First Step.

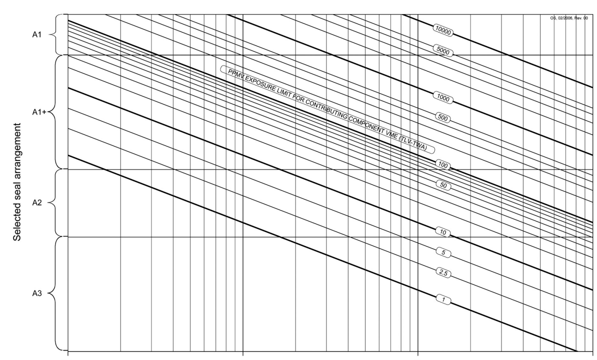

Figure 5.Group II Seal Arrangement Selection Chart.

The user enters this chart with the mass percentage of each of the components within gasoline that are considered dangerous and therefore have personnel exposure limits (Ref 9) dictated by the country in which they will be used. This information is available in sections 3 and 8 of the MSDS and is shown in Figures 6 and 7.

3. COMPOSITION/INFORMATION ON INGREDIENTS

PREPARATION

Chemical nature : Substances composed of paraffin hydrocarbons, naphthenic, aromatic (=< 35%) and olefin hydrocarbons (=< 18%), with mainly hydrocarbons from C4 to C12, including benzene, toluene and n-hexane.
Possibly:
- The following oxygenates compounds: Methanol =< 3% vol, Ethanol =< 10% vol, Isopropyl alcohol =< 10% vol, Isobutyl alcohol =< 10% vol, Terbutyl alcohol =< 7% vol, Ethers (5 or more C atoms) including ETBE/MTBE =< 22% vol.
- Multi-purposes additives to boost performance.

Substances presenting a health hazard	EC No.	CAS No.	Content	Symbol(s)	R-phrases
Gasoline	289-220-8	86290-81-5	>75 %	T ,F+ ,N	R-12, 45, 46, 63, 38, 65, 67, 51/53

See section 16 for explanations of R-phrases :

Composition comments :
- Benzene : CAS 71-43-2, (F; T; R11 - R45 - R46 - R36/38 - R48/23/24/25 - R65) : < 1% vol
- Toluene (CAS: 108-88-3, F; Xn; Xi; Rep.Cat 3; R11 - R48/20 - 65 - R38 - R67 - R63) : < 30% mass
- n-hexane (F - Xn - N - R11-R38-R48/20-R62-R65-R67-R51/53) ......< 5% mass.
- Xylene (CAS: 1330-20-7, Classification CE: R10 - Xn; R20/21 - Xi; R38) : < 30% mass
- Ethylbenzen < 3% mass
- Methanol (EC no. 200-659-6 classification: F, T R11-23/24/25- 39/23/24/25) vol
- Ethanol (Cas 64-17-5, F; Xi. R11 - R36/37) : <= 10% vol
Pentane (iso, n) : < 20% mass
- Trimethylbenzenes (isomers) : < 3% mass

Figure 6. Page 3 of an MSDS Showing Composition and Ingredients.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Technical measures : Use this product in a well-ventilated atmosphere with explosion-proof equipment. When working in confined spaces (tanks, containers, etc.), ensure that there is a supply of air suitable for breathing and wear the recommended equipment.

Occupational exposure limit :
- for GASOLINES: in France none, in the U.S.A (ACGIH) mean exposure limit to gasolines (TLV-TWA) 300 ppm, for 8 hours.
FRANCE, C6 - C12 hydrocarbons vapours : VLE = 1500 mg/m3; VME = 1000 mg/m3.
- For BENZENE in France, VME = 1 ppm (3.25 mg/m3)
n-hexane (FRANCE & EU) : VME=20ppm (72mg/m³)
- For toluene in France : VME=50ppm (192mg/m3), VLE=100ppm (384mg/m3)
- Ethylbenzene (FRANCE) : VME=20ppm (88,4mg/m3), VLE=100ppm (442mg/m3)
FRANCE - Trimethylbenzenes (isomers) :VME=20ppm (100mg/m3), VLE=50ppm (250mg/m3)
FRANCE, xylenes (any isomers) : VME=50ppm (221mg/m3), VLE=100ppm (442mg/m3)
- ISOPENTANE (FRANCE) : VME = 1000ppm (3000mg/m3)
n-Pentane (France) : VME=1000ppm (3000mg/m³)
- Ethylic alcohol (FRANCE) : VME = 1000 ppm (1900 mg/m³); VLE = 5000 ppm (9500 mg/m³)

Figure 7. Page 8 of an MSDS Showing Occupational Exposure Limits.

It can be seen in section 3 of the MSDS that this unleaded gasoline is a complex mixture but that the components that are of concern are gasoline, benezene, n-hexane, toulene, ethylbenzene, trimethylbenzenes (isomers), xylenes (any isomers), isopentane, n-pentane, methanol, and ethanol because they have applicable personnel exposure limits.

The mass percentages given in section 3 are the maximum amounts of each component that gasoline may contain and these are used to enter the Group II seal arrangement selection chart. Sometimes the percentages are given in volume percent, which requires the user to convert to mass percent using Equation (1)

$$\text{Mass\% of component A in mixture B} = \text{vol\% of A in B} \times SgA/SgB \quad (1)$$

Sg = Specific gravity

The personnel exposure limits, for each component, applicable to the country or state where the seal is to be installed, are given in section 8 of the MSDS and for this example are shown in Figure 7. These limits may be given as a threshold limit value for an 8 hour time weighted average (TLV-TWA) or as a 15 minute short term exposure limit (STEL). This procedure uses the TLV-TWA value for safety and because the STEL values are not always given.

As can be seen in Figure 7 the occupational exposure limits are sometimes given in mg/m^3 instead of ppmv. This can be converted to ppmv by using Equation (2).

$$ppmv = 24.45 \times mg/m^3 / \text{molecular weight} \quad (2)$$

For convenience these values have been inserted in Table 9 and are compared to the American Occupational Safety and Health Personnel exposure limits.

Table 9. Comparison of French and US Exposure Limits.

	Wt%	VME ppm France	(TLV-TWA) ppm USA (OSHA)
Gasoline	90	Not specified	300
C6 – C12 Hydrocarbon vapour	90	222 (1000 mg/m3)	Not specified
Benzene	1.22	1	1
n-hexane	5	20	500
Toluene	30	50	200
Ethylbenzene	3	20	100
Trimethylbenzenes (isomers)	3	20	Not specified
Xylenes (any isomers)	30	50	Not specified
Isopentane	20	1000	Not specified
n-pentane	20	1000	1000
Methanol	3	none	Not specified
Ethanol	11	1000	Not specified

Plotting the Table 9 values on the Group II seal arrangement selection chart Figure 5 creates Figure 8, which demonstrates the variation in allowable exposure limits between the two countries and a preliminary seal arrangement selection.

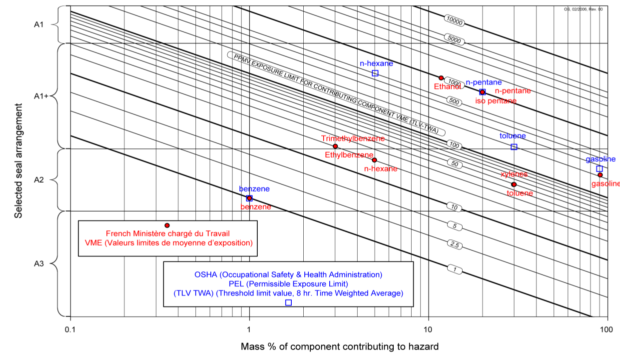

Figure 8. Overlay of Figure 5 with French and US Exposure Limits.

It can be seen that for this selection procedure the gasoline used would require an Arrangement 2 seal due primarily to the benzene content and that a similar gasoline with 2 percent benzene would require an Arrangement 3 seal. It can also be seen that there are different limits for each country and that for a given mixture the seal arrangement may differ between those countries.

Once it has been established that an Arrangement 2 seal is required the user must return to the Seal Arrangement Selection Logic flowchart shown in Figure 9. Replying to the questions leads the user back to an Arrangement 2 seal due to the flashing nature of gasoline and the seal arrangement selection is complete.

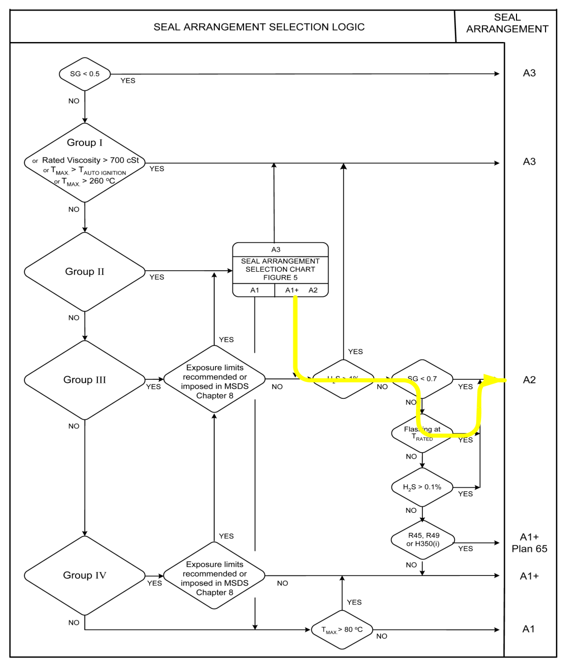

Figure 9. Seal Arrangement Selection Logic Second Step.

PROS AND CONS, A DISCUSSION

To verify the effectiveness of this procedure, the API 682 task force carried out a comparison between this procedure and the procedures of another major oil company and a major seal vendor who used another user proprietary method. The comparison was carried out using the MSDSs of seven different pump applications taken from an actual ongoing project. The results can be seen in Table 10. These results show that the author's company seal selection procedure presented here basically agrees with current practices, but demonstrates a more conservative approach.

Table 10. Comparison with Other Selection Methods.

Description	**Fluid**	**H_2S wt%**	**R phrases**	**Group**	**UK VLE-TWA**	**User**		
						A	**B**	Author's Company
Gas oil feed	Non-flashing HC	0	38 45 46 51/53 63 65	II	none	**A1**	**A1**	**A1**
Lean amine	Amine	0.11	20/22 38 41 48/22	III	DEA 3 ppm H_2S 5 ppm	**A2**	**A2**	**A3**
Hotwell oil (naptha)	Flashing HC	1.8	12 23 38 51/53	III	H_2S 5 ppm	**A3**	**A2**	**A3**
Hydrotreated gas oil	Non flashing HC	0	40 51/53 65 66	III	none	**A1**	**A1**	**A1**
Dryer overhead (naptha)	Flashing HC	0	11 38 45 51/53 65 67	II	none	**A1**	**A1**	**A1**
Oily water	Water + H_2S	Trace	45	II	none	**A1**	**A1**	**A1**
Flare knockout	Sour water	2.5	12 22 23 38 41 45 48/22 51/53 63 65	II	DEA 3 ppm H_2S 5 ppm	**A3**	**A1**	**A3**

This conservatism does not restrict the highly experienced user or purchaser from retaining the basic procedure and writing their own overlay specification by regrouping the H statement codes in a more or less conservative manner according to the users operation and methods. Alternatively moving the selection bands for each arrangement in the Group II seal arrangement selection chart up or down would have a similar effect. Therefore this procedure remains an excellent basis for most users due to the ease with which it can be modified to suit their local requirements, while maintaining a common selection methodology.

This procedure introduces a new requirement that the industry may, at first, find difficult to accept and that is the need for the purchaser to create the MSDS for the fluid to be sealed. This will create a workload that the purchaser is not in the habit of handling and may be onerous during the initial stages of a project when exact fluid compositions may not be available. To assist in such cases users may refer to documents such as the Conservation of Clean Air and Water in Europe (CONCAWE) report 06-05 (Ref 10) for refinery substances and the National Institute for Occupational Safety and Health (NIOSH) pocket guide (Ref 11) to chemical hazards or EU Regulation 1272/2008 Tables 3.1 and 3.2 for chemical substances.

The Concawe report 06-05 has taken all the refinery substances from the EU directives and created very useful subgroups, each with its applicable R phrases. The Concawe report is available as a download and will, no doubt, soon be revised to include the applicable H statements.

Experience has shown that using these documents for an initial selection during early engineering and cost estimating gives a reasonable orientation for seal arrangement selection allowing engineering to continue until the specific composition of the fluid is known.

While the creation of an MSDS may seem to be an increase in workload and hence cost, there are a number of advantages that spin off from this document.

- The MSDS tends to remain with the pump and seal data sheet in the user's archives allowing personnel who were not present during the seal selection to understand how and why the selection was made.

- In the event that the pumped (and seal) fluid changes during the life of the pump, operators can quickly establish if the existing seal meets the new conditions safely by comparing the MSDS of the new fluid to that of the original.

- The detailed composition of the fluid that must be made to establish the MSDS will allow the seal vendors to be more precise in their selections compared to current practice where the fluid is often very loosely described.

- The MSDS is a very valuable document during safety studies such a HAZOP and Risk analysis because they allow those carrying out the analysis to understand better the hazards associated with each fluid.

- Substances that are classified under GHS are regularly reassessed and new substances are added as technology advances and knowledge of those substances improves. This means that a seal chosen for a particular application today may not be correct tomorrow. Therefore this procedure avoids the risk run by many today who select a seal arrangement based on what has been used historically for that particular process stream.

CONCLUSION

The author recognizes that this is a conservative selection procedure; it was created for a company that places safety above all other considerations. A more detailed analysis of each application may reveal alternative seal arrangement and instrumentation solutions that are equally suited to a particular application. The publication of this selection procedure was made primarily to assist those who find themselves in the position of having to purchase a seal without having the depth of knowledge or experience necessary to fine tune the selection to achieve the most cost effective solution. It allows the user to select a seal that will not necessarily be the cheapest, but will be safe for personnel and the environment and as required by local regulations.

REFERENCES

1) ANSI/API Standard 682, 2004, "Pumps—Shaft Sealing Systems for Centrifugal and Rotary Pumps," Third Edition, American National Standards Institute, Washington, D.C./American Petroleum Institute, Washington, D.C. Co-edited as ISO 21049:2004, International Organization for Standardization, Geneva, Switzerland.

2) UN Conference on Environment and Development (UNCED) in Rio de Janeiro, 1992, Identified the harmonization of classification and labeling systems for chemicals as one of its action programs in Chapter 19 of UNCED Agenda 21.

December 2002, the GHS was agreed upon by the UN Committee of Experts on the Transport of Dangerous Goods and the Globally Harmonized System of Classification and Labelling of Chemicals (CETDG/GHS). It was formally adopted by UN Economic and Social Committee (ECOSOC) in July 2003 and revised in 2005 and 2007. In its Plan of Implementation, adopted in Johannesburg on 4 September 2002, the World Summit on Sustainable Development encouraged countries to implement the GHS as soon as possible, with a view to having the system operational by 2008.

3) United Nations Economic Commission for Europe (UNECE) website: http://www.unece.org/trans/danger/publi/ghs/implementation_e.html

4) Council Directive 67/548/EEC of 27 June 1967 on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labeling of dangerous substances.

5) Tables 3.1 and 3.2 of Regulation (EC) No 1272/2008 of the European Parliament and of the Council of 16 December 2008 on classification, labeling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006.

6) Tables 1.1 and 1.2 of Regulation (EC) No 1272/2008 of the European Parliament and of the Council.

7) National Fire Protection Association (NFPA) 704 rating system.

8) Annexe 1 para. 2.6 of Regulation (EC) No 1272/2008 of the European Parliament and of the Council.

9) Threshold Limit Value for an 8 hour Time Weighted Average (TLV–TWA).

10) Conservation of Clean Air and Water in Europe (CONCAWE) Report 06-05. Download at the website: www.concawe.org

11) National Institute for Occupational Safety and Health (NIOSH) Pocket guide to Chemical Hazards, DHHS Publication No 2005-149.