File No: LTD/2038

May 2018

**NATIONAL INDUSTRIAL CHEMICALS NOTIFICATION AND ASSESSMENT SCHEME (NICNAS)**

# PUBLIC REPORT

## Nickel Sulfide ($Ni_3S_2$)

This Assessment has been compiled in accordance with the provisions of the *Industrial Chemicals (Notification and Assessment) Act 1989* (the Act) and Regulations. This legislation is an Act of the Commonwealth of Australia. The National Industrial Chemicals Notification and Assessment Scheme (NICNAS) is administered by the Department of Health, and conducts the risk assessment for public health and occupational health and safety. The assessment of environmental risk is conducted by the Department of the Environment and Energy.

This Public Report is available for viewing and downloading from the NICNAS website or available on request, free of charge, by contacting NICNAS. For requests and enquiries please contact the NICNAS Administration Coordinator at:


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**Director**
**NICNAS**

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# SUMMARY

The following details will be published in the NICNAS *Chemical Gazette:*

| ASSESSMENT REFERENCE | APPLICANT(S) | CHEMICAL OR TRADE NAME | HAZARDOUS CHEMICAL | INTRODUCTION VOLUME | USE |
|---|---|---|---|---|---|
| LTD/2038 | Viva Energy Refining Pty Ltd | Nickel Sulfide ($Ni_3S_2$) | Yes | < 1 tonne per annum | Component of catalysts used in petroleum industry |

# CONCLUSIONS AND REGULATORY OBLIGATIONS

**Hazard classification**
Based on the available information, the notified chemical is recommended for hazard classification according to the *Globally Harmonised System of Classification and Labelling of Chemicals (GHS),* as adopted for industrial chemicals in Australia. The recommended hazard classification is presented in the following table.

| *Hazard classification* | *Hazard statement* |
|---|---|
| Acute toxicity (Category 4) | H332 – Harmful if inhaled |
| Skin sensitisation (Category 1) | H317 – May cause an allergic skin reaction |
| Mutagenicity (Category 2) | H341 – Suspected of causing genetic defects |
| Carcinogenicity (Category 1A) | H350 – May cause cancer by inhalation |
| Specific target organ toxicity (repeated exposure) (Category 1) | H372 – Causes damage to organs (lungs) through prolonged or repeated exposure by inhalation |

The environmental hazard classification according to the *Globally Harmonised System of Classification and Labelling of Chemicals* (GHS) is presented below. Environmental classification under the GHS is not mandated in Australia and carries no legal status but is presented for information purposes.

| *Hazard classification* | *Hazard statement* |
|---|---|
| Acute toxicity (Category 1) | H400 – Very toxic to aquatic life |
| Chronic toxicity (Category 1) | H410 – Very toxic to aquatic life with long lasting effects |

**Human health risk assessment**
Provided that the recommended controls are being adhered to, under the conditions of the occupational settings described, the notified chemical is not considered to pose an unreasonable risk to the health of workers.

When used in the proposed manner, the notified chemical is not considered to pose an unreasonable risk to public health.

**Environmental risk assessment**
On the basis of the reported use pattern, the notified chemical is not considered to pose an unreasonable risk to the environment.

**Recommendations**

REGULATORY CONTROLS

Hazard Classification and Labelling

- The notified chemical should be classified as follows:
  - Acute Toxicity (Category 4): H332 – Harmful if inhaled
  - Skin Sensitisation (Category 1): H317 – May cause an allergic skin reaction
  - Mutagenicity (Category 2): H341 – Suspected of causing genetic defects

- Carcinogenicity (Category 1A): H350 – May cause cancer by inhalation
- Specific target organ toxicity (repeated exposure) (Category 1): H372 – Causes damage to organs (lungs) through prolonged or repeated exposure by inhalation

The above should be used for products/mixtures containing the notified chemical, if applicable, based on the concentration of the notified chemical present.

Health Surveillance

- As the notified chemical is considered to be a skin sensitiser and carcinogen, employers should carry out health surveillance for any worker who has been identified in the workplace risk assessment as having a significant risk of adverse health effects.

CONTROL MEASURES

Occupational Health and Safety

- A person conducting a business or undertaking at a workplace should implement the following engineering controls to minimise occupational exposure to the notified chemical when introduced in petroleum refinery catalysts:
  - Isolated, automated and specialised processes
  - Inert atmospheric environment when storing, loading and unloading the catalysts

- A person conducting a business or undertaking at a workplace should implement the following safe work practices to minimise occupational exposure when handling the catalysts containing the notified chemical:
  - Use specialised personnel to handle the catalysts
  - Keep the catalysts in an isolated inert environment where possible
  - Avoid leaks and spills
  - Avoid contact with skin and eyes
  - Avoid inhalation if dusts or aerosols are suspected

- A person conducting a business or undertaking at a workplace should ensure that the following personal protective equipment is used by workers when handling the catalysts to minimise occupational exposure to the notified chemical:
  - Specialised full body hazmat suit
  - Life support unit with self-contained respiratory system

  Guidance in selection of personal protective equipment can be obtained from Australian, Australian/New Zealand or other approved standards.

- A copy of the SDS should be easily accessible to employees.

- If products and mixtures containing the notified chemical are classified as hazardous to health in accordance with the *Globally Harmonised System of Classification and Labelling of Chemicals (GHS)* as adopted for industrial chemicals in Australia, workplace practices and control procedures consistent with provisions of State and Territory hazardous substances legislation should be in operation.

Disposal

- A person conducting a business or undertaking at a workplace should regenerate catalysts containing the notified chemical or reclaim metal to the extent practicable. Landfill disposal or incineration must not be carried out without prior consent from relevant Commonwealth, state, territory and local government authorities.

Storage

- The handling and storage of the notified chemical should be in accordance with the Safe Work Australia Code of Practice for *Managing Risks of Hazardous Chemicals in the Workplace* (SWA, 2012) or relevant State or Territory Code of Practice.
- The following precautions should be taken regarding storage of the notified chemical:
  - Isolated storage

Emergency procedures

- Spills or accidental release of the notified chemical should be handled by physical containment, collection and subsequent re-use or metal reclamation to the extent practicable. Any disposal requires prior consent from appropriate local, State and Federal government authorities.

**Regulatory Obligations**

*Secondary Notification*
This risk assessment is based on the information available at the time of notification. The Director may call for the reassessment of the chemical under secondary notification provisions based on changes in certain circumstances. Under Section 64 of the *Industrial Chemicals (Notification and Assessment) Act (1989)* the notifier, as well as any other importer or manufacturer of the notified chemical, have post-assessment regulatory obligations to notify NICNAS when any of these circumstances change. These obligations apply even when the notified chemical is listed on the Australian Inventory of Chemical Substances (AICS).

Therefore, the Director of NICNAS must be notified in writing within 28 days by the notifier, other importer or manufacturer:

(1) Under Section 64(1) of the Act; if
  - the importation volume exceeds one tonne per annum notified chemical;

or

(2) Under Section 64(2) of the Act; if
  - the function or use of the chemical has changed from component of catalysts used in petroleum industry, or is likely to change significantly;
  - the amount of chemical being introduced has increased, or is likely to increase, significantly;
  - the method of manufacture of the chemical in Australia has changed, or is likely to change, in a way that may result in an increased risk of an adverse effect of the chemical on occupational health and safety, public health, or the environment;
  - additional information has become available to the person as to an adverse effect of the chemical on occupational health and safety, public health, or the environment.

The Director will then decide whether a reassessment (i.e. a secondary notification and assessment) is required.

*Safety Data Sheet*
The SDS of the products containing the notified chemical provided by the notifier was reviewed by NICNAS. The accuracy of the information on the SDS remains the responsibility of the applicant.

# ASSESSMENT DETAILS

## 1. APPLICANT AND NOTIFICATION DETAILS

APPLICANT(S)
Viva Energy Refining Pty Ltd (ABN: 46 004 303 842)
10 Refinery Road
CORIO VIC 3214

NOTIFICATION CATEGORY
Limited-small volume: Chemical other than polymer (1 tonne or less per year)

EXEMPT INFORMATION (SECTION 75 OF THE ACT)
No details are claimed exempt from publication.

VARIATION OF DATA REQUIREMENTS (SECTION 24 OF THE ACT)
Variation to the schedule of data requirements is claimed for all physical and chemical properties.

PREVIOUS NOTIFICATION IN AUSTRALIA BY APPLICANT(S)
None

NOTIFICATION IN OTHER COUNTRIES
REACH (EU), 2010

## 2. IDENTITY OF CHEMICAL

MARKETING NAME(S)
Nickel subsulfide

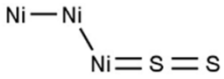
CAS NUMBER
12035-72-2

CHEMICAL NAME
Nickel sulfide ($Ni_3S_2$)

OTHER NAME(S)
Trinickel disulfide

MOLECULAR FORMULA
$Ni_3S_2$

STRUCTURAL FORMULA




MOLECULAR WEIGHT
240.2 g/mol

## 3. COMPOSITION

DEGREE OF PURITY
100 %

ADDITIVES/ADJUVANTS

| | | | |
|---|---|---|---|
| *Chemical Name* | Aluminium oxide | | |
| *CAS No.* | 1344-28-1 | *Weight %* | ≤ 70% |

| | | | |
|---|---|---|---|
| *Chemical Name* | Molybdenum disulfide | | |
| *CAS No.* | 1317-33-5 | *Weight %* | ≤ 20% |
| *Chemical Name* | Phosphoric acid, aluminum salt (1:1) | | |
| *CAS No.* | 7784-30-7 | *Weight %* | ≤ 10% |

## 4. PHYSICAL AND CHEMICAL PROPERTIES

APPEARANCE AT 20 °C AND 101.3 kPa: Grey solid

| Property | Value | Data Source/Justification |
|---|---|---|
| Melting Point/Freezing Point | > 633 K (360 °C) | Measured |
| Density | 5,980 kg/m$^3$ at 23 °C | Measured |
| Vapour Pressure | Not determined | Inorganic solid with melting point > 360 °C |
| Water Solubility | 15.8 mg/L at 20 °C after 144 h* | Measured |
| Hydrolysis as a Function of pH | Not determined | Inorganic solid |
| Partition Coefficient (n-octanol/water) | Not determined | Inorganic solid |
| Adsorption/Desorption | Not determined | Expected to settle to sediment and sludge based on low solubility in water |
| Dissociation Constant | Not determined | Inorganic solid |
| Particle Size | Not determined | Imported as ready-do-use pellets in catalysts^ |
| Flash Point | Not determined | Inorganic solid with melting point > 360 °C |
| Flammability | Not highly flammable | Measured |
| Autoignition Temperature | > 400 °C | Measured |
| Explosive Properties | Not determined | Contains no functional groups that imply explosive properties |
| Oxidising Properties | Not determined | Contains no functional groups that imply oxidative properties |

* The figure was calculated based on total dissolved nickel content after 144 h. The saturation concentration has not been reached at this time.
^ The notified chemical is impregnated on alumina pellets.

DISCUSSION OF PROPERTIES
No full detailed study reports of the above measured physical chemical properties were provided. The study summaries for the notified chemical were provided (REACH).

*Reactivity*
The notified chemical is expected to be stable under normal conditions of use.

The catalysts containing the notified chemical are based on aluminium oxide, which may adsorb oxygen from the atmosphere and cause the notified chemical to undergo oxidation and self-heating.

***Physical hazard classification***
Based on the submitted physico-chemical data depicted in the above table, the notified chemical cannot be recommended for hazard classification according to the *Globally Harmonised System of Classification and Labelling of Chemicals* (GHS), as adopted for industrial chemicals in Australia.

Due to potential self-heating properties of the catalysts, products containing the notified chemical may be considered as dangerous goods Class 4.2, UN 3190, self-heating solid, inorganic, not otherwise specified (N.O.S.) under *Australian Code for the Transport of Dangerous Goods by Road and Rail* (NTC, 2017).

## 5. INTRODUCTION AND USE INFORMATION

MODE OF INTRODUCTION OF NOTIFIED CHEMICAL (100%) OVER NEXT 5 YEARS
The notified chemical will be either manufactured (through catalyst activation processes) in Australia or imported into Australia as part of catalyst products (in an activated ready to use form) at ≤ 10% concentration.

MAXIMUM INTRODUCTION VOLUME OF NOTIFIED CHEMICAL (100%) OVER NEXT 5 YEARS

| *Year* | *1* | *2* | *3* | *4* | *5* |
|---|---|---|---|---|---|
| *Tonnes* | < 1 | < 1 | < 1 | < 1 | < 1 |

PORT OF ENTRY
Melbourne

IDENTITY OF MANUFACTURER/RECIPIENTS
Viva Energy Refining Pty Ltd

TRANSPORTATION AND PACKAGING
The imported catalysts containing the notified chemical (at ≤ 10% concentration) will be packed in sealed 200 L steel drums, and transported from the port to the refineries by road tankers. The catalysts containing the notified chemical may be temporarily stored in the sealed containers in an isolated area until further deployment into the refinery reactors.

Due to potential self-heating properties of the catalysts, introducers of the notified chemical will follow their obligations under *Australian Code for the Transport of Dangerous Goods by Road and Rail* (ADG code) (NTC, 2017).

USE
The notified chemical, impregnated on alumina pellets, will be introduced into Australia (at ≤ 10% concentration) as a component of solid hydrotreating catalysts for use in the petroleum refining industry.

OPERATION DESCRIPTION

*Manufacture*
The hydrotreating catalysts imported into Australia will usually be supplied in either oxide or sulfide form. The oxide form of the catalysts loaded into the reactors will need to be activated through *in situ* pre-sulfiding during the process unit start-up phase. The metal oxides including nickel and molybdenum will then be converted into metal sulphides including $Ni_3S_2$, the notified chemical. As the activation process will produce the notified chemical, it is therefore considered to be a manufacturing process. The activation process will be conducted by specialise catalyst loading contractors in a well-controlled manner at the site of loading, and the $Ni_3S_2$ generated will be enclosed and directly used within the process unit.

*Loading and Unloading*
The catalyst products containing the notified chemical (at ≤ 10% concentration) will be loaded from the steel drums into enclosed reactors by specialised catalyst loading contractors using refilling equipment under an inert atmosphere with sufficient personal protections according to well documented procedures. The catalysts containing the notified chemical are expected to last for six years in the reactors. At the end of usable life, the used catalysts will be unloaded into appropriate containers by the specialised contractors using gravity and maintained under inert atmosphere. The used catalysts will then be sent offsite for regeneration or disposed of according to relevant Commonwealth, state, territory and local government legislation. Fresh catalysts will be re-loaded into the reactors.

## 6. HUMAN HEALTH IMPLICATIONS

### 6.1. Exposure Assessment

#### 6.1.1. Occupational Exposure

CATEGORY OF WORKERS

| *Category of Worker* | *Exposure Duration (hours/day)* | *Exposure Frequency (days/6 years)** |
|---|---|---|
| Truck/Forklift drivers | 12 | 4 |
| Catalyst-handling contractors | 12 | 4 |
| Refinery personnel | 12 | 4 |

* Usage of the notified chemical will be limited to once every 6 years.

EXPOSURE DETAILS
It is anticipated that transport and storage workers would only be exposed to the notified chemical in the event of an accident.

At the end-use sites, exposure via all potential routes to the notified chemical at ≤ 10% concentration may be possible but is expected to be kept minimal by the professional personnel during opening of the steel drums containing the notified chemical, loading the catalysts to reactors using refilling equipment, bale packing of used bags and cleaning/maintenance processes. Given the reactivity and hazardous nature of the catalysts containing the notified chemical, special engineering controls such as isolated, automated and specialised processes, inert atmospheric environment, and atmospheric monitoring will be in place. Personal protective equipment (PPE) including hazmat life support suits and self-contained respiratory systems will also be used by specialised loading contractors to handle the catalysts. The catalysts will be loaded into the reactor vessels over a period of several hours to a few days by qualified contractors. Once the catalysts are loaded into the reactors, the notified chemical is expected to remain in enclosed systems over a period of approximately 6 years and will not be available for exposure during the normal use.

Normal refinery workers are only expected to be responsible for on-site transport of the catalysts containing the notified chemical or conducting maintenance on the machinery when it is not in use. These workers are not expected to be exposed to the notified chemical during the hydroprocessing processes.

### 6.1.2. Public Exposure
Catalyst products containing the notified chemical are specialised to refinery industry only and will not be made available to the general public. Members of the public may come into contact with fuels processed using catalysts containing the notified chemical. However, the notified chemical is not expected to be released into fuels during the refining process.

## 6.2. Human Health Effects Assessment
The results from toxicological investigations conducted on the notified chemical are summarised in the following table.

| *Endpoint* | *Result and Assessment Conclusion* |
|---|---|
| Rat, acute oral toxicity | LD50 > 11,000 mg/kg bw; low toxicity |
| Rat, acute inhalation toxicity (dust) | LC50 = 1.02 mg/L/4 hour; harmful |
| Rabbit, skin irritation | slightly irritating |
| Rabbit, eye irritation | slightly irritating |
| Skin sensitisation | evidence of sensitisation* |
| Rat, repeat dose inhalation toxicity – 2 years. | LOAEC = 0.15 mg/m$^3$ |
| Mutagenicity – *in vitro* mammalian cell gene mutation | inadequate evidence for mutagenicity |
| Genotoxicity – *in vivo* mammalian erythrocyte micronucleus test (intraperitoneal injection) | evidence of clastogenicity |

* Based on the content of $Ni^{2+}$

No full detailed toxicology study reports were provided. The study summaries for the notified chemical were provided (REACH).

*Toxicokinetics, metabolism and distribution*
Based on a study summary provided, the notified chemical was administered to rats by oral gavage at a dose level of 10 mg in 5% saline and the animals were sacrificed 24 hr after dosing. Nickel (Ni) concentrations were measured in lung, liver, kidney, spleen, pancreas, heart, blood, and brain via atomic absorption spectrophotometry. Relative to control tissues, Ni levels were significantly elevated in the lung (0.17 vs. 0.04 µg/g), liver (0.07 vs. 0.03 µg/g), and kidney (1.2 vs. 0.03 µg/g). However, only 0.47% of the total administered Ni was measurable in organs, blood or urine. The authors concluded that the solubility of the Ni compound is one of the important factors for determining the health effects (NICNAS).

In a study conducted similarly to OECD TG 417, male rats were exposed by inhalation to 5.7 mg/m$^3$ of radiolabelled notified chemical for 120 minutes. Based on the rate of delivery, 175 µg was inhaled and 24.6 µg (14 %) was recovered in all tissues and fluids. Of the recovered nickel, 66% was deposited in the upper respiratory tract and 34% in the lower respiratory tract. Nickel was not detected in the lungs of the animals euthanised 32 days after the exposure and therefore a clearance half-time of 4.6 days was estimated for nickel. It

was also suggested that nickel may have been transferred from the lung to associated lymph nodes and hence cleared from the lung (NICNAS).

*Acute toxicity*
Based on the study summary submitted, the notified chemical showed low acute toxicity to female rats tested through a single oral exposure. The median lethal dose (LD50) was considered by the study authors to be > 11,000 mg/kg bw. No signs of gross toxicity, adverse clinical effects or abnormal behaviour were observed (REACH).

In an acute inhalation toxicity study conducted according to OECD TG 403, 5 male and 5 female rats in each dose group were exposed to the notified chemical in dust form at dose levels of 0.206, 1.02 or 5.15 mg/L (with a mass median aerodynamic diameter of 3.1 - 3.35 μm) for 4 hours. All animals appeared to be active and healthy immediately following the exposure. On Day 3, animals exposed to 1.02 mg/L were reported to show signs of facial staining, irregular respiration and hypoactivity. There were a total of four mortalities (one male and three females) at this dose level on Days 4 – 7. All animals in 5.15 mg/L dose group were found dead or moribund by Day 5. In addition the adverse effects reported above, hunched posture and reduced food consumption correlated with reduced faecal volume at the dose level of 5.15 mg/L were also reported (NICNAS, REACH). Based on the study, LC50 of the notified chemical was considered to be at 1.02 mg/L/4 hour and the chemical was deemed harmful if inhaled.

*Irritation*
Based on study summaries provided, skin irritation studies in accordance with OECD TG 404 were performed on New Zealand White rabbits under semi-occlusive conditions. The notified chemical was applied to the shaved skin of rabbits at 85% concentration by weight for 4 hours and the animals were observed for 72 hours. Application sites showed signs of slight erythema within 1 hour of patch removal which was reversible within 72 hours. No further signs of gross toxicity, adverse effects or abnormal behaviour were noted (REACH).

Eye irritation studies in accordance with OECD TG 405 were performed on New Zealand White rabbits. The notified chemical (0.1 g) was instilled into one eye of the rabbits and the animals were observed for 72 hours. All treated eyes exhibited corneal opacity, iritis and conjunctivitis 1 hour after instillation which resolved within 72 hours. No further signs of gross toxicity, adverse effects or abnormal behaviour were noted (REACH).

Based on the results of these studies, the notified chemical is considered to be slightly irritating to the skin and eyes; however, classification as a skin or eye irritant was not warranted.

*Sensitisation*
$Ni^{2+}$ ion is a known significant inducer of skin sensitisation (ATSDR, 2005) and nickel metal is also classified as a Category 1 skin sensitiser (HCIS, Safe Work Australia). Based on available bioelution data, the release of the $Ni^{2+}$ ion from the notified chemical into artificial sweat is 8.6 times greater compared with nickel metal (NICNAS). Therefore, the notified chemical is considered to be a Category 1 skin sensitiser.

*Repeated dose toxicity*
No data for repeated dose toxicity via the oral or dermal route are available for the notified chemical.

The National Toxicology Program (NTP, 1996) conducted 13-week and 2-year repeated dose inhalation studies in rats and mice (similar to OECD TG 453) using the notified chemical.

13-Week Studies
Studies were conducted in both rats and mice. A total of 10 males and 10 females in each treatment group were exposed to 0, 0.15, 0.3, 0.6, 1.2 or 2.5 mg/m$^3$ of notified chemical via inhalation for 6 hours a day, 5 days a week, for 13 weeks.

In rats, observed adverse effects included laboured respiration in the highest dose group (2.5 mg/m$^3$). The male rats in this group also had reduced body weight and body weight gain. Compared with controls, the relative lung weights were significantly increased in all exposure groups. Haematological markers including neutrophil and erythrocyte counts were minimally increased. Adverse effects of the lung included a significant increase in the number of alveolar macrophages, interstitial infiltration and chronic inflammation in the animals exposed to ≥ 0.3 mg/m$^3$ of the notified chemical. Furthermore, lymphoid hyperplasia of the bronchial and mediastinal lymph nodes was observed and atrophy of the nasal olfactory epithelium increased showing dose response (NTP, 1996).

In mice, similar adverse effects were reported. However, in contrast to the study with rats, body weight or body weight gain was not affected. Relative lung weights of female mice exposed to 1.2 or 2.5 mg/m$^3$ were significantly increased. Lung specific effects included a significant increase in alveolar macrophages at exposure concentration ≥ 0.3 mg/m$^3$. Other lung effects included chronic inflammation, fibrosis and bronchial lymph node hyperplasia at ≥ 1.2 mg/m$^3$. The severity of atrophy of the nasal olfactory epithelium also increased showing dose response (NTP, 1996).

2-Year Studies
Studies were also conducted in both rats and mice.

In rats, 63 males and 63 females in each group were exposed to 0, 0.15 or 1 mg/m$^3$ of the notified chemical for 6 hours a day, 5 days a week for 2 years. Exposure to the notified chemical did not affect survival when compared with the controls. Observable adverse effects included rapid and shallow breathing following each exposure period. Lung-specific effects included a significant increase in lung weights compared with the controls across both exposure groups when assessed at 7 and 15 month observation time points. Non-neoplastic lung pathological changes included fibrosis, chronic active inflammation and bronchial lymph node hyperplasia, which were significantly increased in both males and females exposed to the notified chemical. There was also a significant increase in atrophy of the olfactory epithelium in both males and females and chronic active inflammation in the noses of the females at the dose of 1 mg/m$^3$ (NTP, 1996).

In mice, 80 males and 80 females in each group were exposed to 0, 0.6 or 1.2 mg/m$^3$ of the notified chemical under the same conditions as in rats. The exposure did not affect survival. Observable adverse effects also included rapid and shallow breathing following each exposure period. Lung-specific effects included a significant increase in lung weights across both exposure groups when assessed at 7 and 15 month time points. Similar to rats, non-neoplastic lung pathological changes were noted for fibrosis, chronic active inflammation and bronchial lymph node hyperplasia, increasing in both males and females exposed to the notified chemical at an exposure concentration ≥ 0.6 mg/m$^3$. There was also a significant increase in atrophy of the olfactory epithelium in both males and females and a significant increase in acute inflammation and degeneration of the olfactory epithelium in females at an exposure concentration ≥ 0.6 mg/m$^3$ (NTP, 1996).

Based on the 2-year study in rats, a lowest observed adverse effect concentration (LOAEC) of 0.15 mg/m$^3$ for non-neoplastic lung toxicity was reported for the notified chemical, warranting hazard classification.

*Mutagenicity/Genotoxicity*
Based on the study summaries provided, *in vitro* mammalian cell gene mutation studies were carried out on the notified chemical. In initial studies, the notified chemical was found to be mutagenic at 1.4 mM and 1.0 mM with and without metabolic activation, respectively. The positive results without metabolic activation could not be repeated in a subsequent test. However, the highest concentration used in the repeat study was 0.5 mM. The study authors considered that the observed mutagenicity might be the result of high cytotoxicity accompanied precipitation of the test substance, and therefore the evidence for mutagenicity was considered by the study authors to be inconclusive under the conditions of the studies (REACH).

An *in vivo* mammalian erythrocyte micronucleus test was carried out in mice that received a single intraperitoneal (i.p.) injection of the notified chemical suspended in 1% carboxymethyl cellulose. A prior experiment with 250, 500 and 1,000 mg/kg bw determined the dose levels were suitable for the micronucleus test. Control and treated animals, 10 animals per group, were sacrificed at 24, 48, and 72 hours after exposure and the femoral bone marrow cells were harvested. Cyclophosphamide at 50 mg/kg was used as a positive control. Animals treated with the notified chemical exhibited a significant decrease in polychromatic erythrocytes (PCEs) at 24 and 48 hours after the treatment, which the authors noted as evidence for bone marrow toxicity. PCEs comprised 72% and 71% of 200 bone marrow cells evaluated in the vehicle and positive control groups respectively, and only 44% in the animals treated with 250 mg/kg bw of the notified chemical. The number of micronuclei in PCEs from treated animals was significantly elevated at 24, 48, and 72 hr after exposure with average numbers of 3.4, 2.1 and 1.5 respectively. Ni content data in the femoral bone marrow cells taken from treated animals demonstrated that i.p. injection of the notified chemical at levels ≥ 250 mg/kg bw resulted in the nickel content reaching the bone marrow. It was concluded by the study authors that the notified chemical can cause clastogenic effects *in vivo* (REACH).

Based on the GHS (Paragraph 3.5.2.10), the relevance of the route of exposure used in the study compared to the route of human exposure should be taken into account when considering the total weight of evidence for

mutagenicity classification (United Nations, 2009). It is noted that i.p. injection may not be a relevant route of exposure for human as per use pattern assessed for the notified chemical. However, based on the information available, the notified chemical has been classified as a Category 2 mutagen in the European Union (https://echa.europa.eu/information-on-chemicals/cl-inventory-database/-/discli/details/27686). In the safety data sheets (SDS) provided, the catalysts containing the notified chemical are also classified as Category 2 mutagens.

*Carcinogenicity*
In the 2-year repeated dose inhalation study conducted with rats (NTP, 1996), there was a significant increase in the number of alveolar/bronchiolar adenomas or carcinomas in male and female rats treated at 1 mg/m$^3$ of the notified chemical. Furthermore, there was a significant increase in the number of bilateral neoplastic lesions of the adrenal medulla in males treated at ≥ 0.15 mg/m$^3$ and females treated at 1 mg/m$^3$.

Compared with the 2-year study in rats, the 2-year study in mice did not report a significant increase in the number of alveolar/bronchiolar adenomas or carcinomas in males or females (NTP, 1996).

$Ni^{2+}$ compounds have been classified as a Category 1A carcinogenic substances with the risk statement of 'May cause cancer by inhalation' (H350i under GHS) in HCIS (Safe Work Australia). The International Agency for Research on Cancer (IARC) has classified nickel compounds as 'Carcinogenic to humans' (Group 1). IARC has highlighted studies with an increased risk of lung cancer from exposure to nickel compounds, although these were often mixed exposures, either with soluble nickel or oxidic nickel compounds. A cohort of nickel plant (Clydach, United Kingdom) cleaners exposed to insoluble nickel compounds (oxidic and sulfidic mainly) were reported to have a high rate of lung cancer (IARC, 2012).

The above observations in animals and human support the classification of the notified chemical to be a Category 1A carcinogen.

*Toxicity for reproduction*
No data for reproductive and developmental toxicity are available for the notified chemical. Bioaccessibility studies have demonstrated that the release of the $Ni^{2+}$ ion from nickel compounds is similar to that of nickel oxide in artificial gastric fluid (Henderson et al., 2012). The weight of evidence from available data suggests a lack of sufficient *in vivo* bioavailability by oral, inhalation and dermal routes, and no classification for reproductive toxicity of the notified chemical can be warranted (REACH, NICNAS).

***Health hazard classification***
Based on the available information, the notified chemical is recommended for hazard classification according to the *Globally Harmonised System of Classification and Labelling of Chemicals (GHS),* as adopted for industrial chemicals in Australia. The recommended hazard classification is presented in the following table.

| *Hazard classification* | *Hazard statement* |
|---|---|
| Acute Toxicity (Category 4) | H332 – Harmful if inhaled |
| Skin sensitisation (Category 1) | H317 – May cause an allergic skin reaction |
| Mutagenicity (Category 2) | H341 – Suspected of causing genetic defects |
| Carcinogenicity (Category 1A) | H350 – May cause cancer by inhalation |
| Specific target organ toxicity (repeated exposure) (Category 1) | H372 – Causes damage to organs (lungs) through prolonged or repeated exposure by inhalation |

### 6.3. Human Health Risk Characterisation

#### 6.3.1. Occupational Health and Safety
Based on the available information, the notified chemical presents a concern for a number of acute and chronic health effects, including skin sensitisation, mutagenicity, carcinogenicity and damage to lungs. Therefore, exposure via any route to the notified chemical should be avoided.

Nickel, soluble compounds (as Ni) have an exposure standard set by Safe Work Australia (HCIS, http://hcis.safeworkaustralia.gov.au/ExposureStandards/Details?exposureStandardID=432), with a time weighted average (TWA) of 0.1 mg/m$^3$. The notifier has indicated that the notified chemical will be imported as ready to use catalysts impregnated on alumina pellets, stored and transported in sealed containers, with no inhalable

particles (< 100 μm) present. Apart from loading and unloading of the catalysts, operating processes involving the notified chemical are expected to be automated and occur in isolated and well-controlled environments.

Exposure to the notified chemical may potentially occur during loading and unloading of the catalysts containing the notified chemical at ≤ 10% concentration. The operations will be conducted by specialised contractors using refilling equipment under an inert atmosphere with life support protective suits and self-contained respiratory systems according to well documented procedures. Potential for exposure to the notified chemical will be kept minimal. Unsealed catalysts containing the notified chemical will only be handled by the specialised contractors and are not expected to be accessible to refinery workers. The loading and unloading operations will only occur once every 6 years.

The catalysts containing the notified chemical are expected to deplete during refinery operations. At the end of the usable life, the catalysts will be replaced. During the refinery operations the notified chemical is not expected to be released into finished petroleum fuels.

Overall, provided control measures are in place to minimise exposure of specialised workers to the notified chemical, including the use of automated processes, isolated inert environments and special PPE, the risk to workers from use of the notified chemical is not considered to be unreasonable.

#### 6.3.2. Public Health

Catalyst products containing the notified chemical are specialised to refinery industry only and will not be made available to the general public. Spent catalysts will be collected for regeneration or disposal in specialised facilities.

Members of the public may come into contact with fuels processed using catalysts containing the notified chemical. However, the notified chemical is not expected to be released into finished fuels during the refining process.

When used in the proposed manner, the notified chemical is not considered to pose an unreasonable risk to public health.

## 7. ENVIRONMENTAL IMPLICATIONS

### 7.1. Environmental Exposure & Fate Assessment

#### 7.1.1. Environmental Exposure

RELEASE OF CHEMICAL AT SITE

The catalysts containing the notified chemical will be imported into Australia either in a “ready to use” form or in oxide forms which need to be activated through *in-situ* pre-sulfiding during the process unit start-up phase. During the start-up, metal oxides including nickel and molybdenum will be converted into metal sulfides including the notified chemical. The activation process will be conducted by specialised catalyst loading contractors in a well-controlled manner at the site of loading. The catalyst products containing the notified chemical will be loaded into enclosed reactors using refilling equipment under an inert atmosphere according to well documented procedures. In the unlikely event of accidental spills or leaks during storage, transport, activation and loading, the notified chemical is expected to be collected for re-use or metal reclamation to the extent practicable. Disposal requires prior consent from appropriate local, State and Federal government authorities.

RELEASE OF CHEMICAL FROM USE

The notified chemical will be used as a component of solid hydrotreating catalysts in the petroleum refining industry. The catalysts containing the notified chemical will become depleted during the hydrotreating process after approximately 6 years, leaving residual sufides and oxides of nickel and molybdenum. No release to the environment is expected.

RELEASE OF CHEMICAL FROM DISPOSAL

At the end of its usable life, the used catalysts will be unloaded into appropriate containers by the specialised contractors using gravity and maintained under inert atmosphere. The used catalysts will then be sent off-site for regeneration or metal reclamation to the extent practicable. Any disposal requires prior consent from appropriate local, State and Federal government authorities.

### 7.1.2. Environmental Fate

The notified chemical will be reacted in enclosed reactors over a 6 year period to form sulfides and oxides of nickel, with no expected environmental release.

Nickel does not bioaccumulate in aquatic biota, and in general does not biomagnify. According to the information provided, the most representative Bioconcentration Factor (BCF) value for aquatic organisms and bioaccumulation factor (BAF) for earthworms are 270 L/kg and 0.3, respectively. It would also appear that many aquatic organisms have the ability to regulate nickel uptake in the concentration range of 1 – 100 µg/L.

### 7.1.3. Predicted Environmental Concentration (PEC)

The Predicted Environmental Concentration (PEC) has not been calculated as release of the notified chemical to the aquatic environment is not expected based on its reported use pattern.

### 7.2. Environmental Effects Assessment

Results from the ecotoxicological investigation conducted on the notified chemical are summarised in the table below. Details of these studies were provided (REACH).

| *Endpoint* | *Result* | *Assessment Conclusion* |
|---|---|---|
| Fish Toxicity | 96 h EC50 = 400 µg Ni/L | Toxic to fish |
| Daphnia Toxicity | 48 h EC50 = 13 µg Ni/L | Very toxic to invertebrates |
| Algal Toxicity | EC50 = 58.8 µg Ni/L | Very toxic to algal |

Under the *Globally Harmonised System of Classification and Labeling of Chemicals* (GHS), the notified chemical is expected to be very toxic to aquatic organisms. Therefore, the notified chemical is formally classified as "Acute Category 1; Very toxic to aquatic life" under the GHS. Based on the acute toxicity and lack of readily biodegradation, the notified chemical is formally classified as "Chronic Category 1; Very toxic to aquatic life with long lasting effects" under the GHS (United Nations, 2009).

### 7.2.1. Predicted No-Effect Concentration

The Predicted No-Effect Concentration (PNEC) has not been calculated as release of the notified chemical to the aquatic environment is not expected based on its reported use pattern.

### 7.3. Environmental Risk Assessment

The Risk Quotient (PEC/PNEC) for the aquatic compartment has not been calculated as release of the notified chemical to the aquatic environment is not expected based on its reported use pattern.

Therefore, on the basis of the reported use pattern as a component of solid hydrotreating catalysts in the petroleum refining industry, the notified chemical is not considered to pose an unreasonable risk to the environment.

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