Höganäs

Manganese sulphide (MnS)
Exposure Scenario

Version 2, May 2017

2 Manufacture of Powder Metallurgy (PM) mixes, including packaging of PM mix

2.1 ES 2: Manufacture of Powder Metallurgy (PM) mixes, including packaging of PM mix(IU1) (ES 2) (SU3, 10; PROC 3, 4, 5, 8b; PC not applicable; AC not applicable) – IU 1

For IU1, this is a formulation process, where MnS is added to other co-formulants to make a PM (powder metallurgy) mix.

Description of activities and processes covered in the exposure scenario

It is assumed that some exposure can occur to the milled/sieved pure 100% MnS when it is transferred to the PM mixing vessel (**PROC 8b**). It is assumed that low exposure will subsequently occur to dust containing 0.3% MnS during formulation of the PM mix of MnS and other co-formulants (with varying degrees of closed system from **PROC 3, 4, 5**), and that exposure to the resulting PM mix (containing 0.3% MnS) can occur when it is transferred from the mixing vessel to the big-bag (**PROC 8b**).The scenario is also expanded to assess exposure to higher concentrations of MnS if this is required.

Operational conditions

PM mixes can be produced up to 365 days per year. The production can run up to 24 hours a day, which would require 2 or 3 shifts of 8 hours or more, dependent on working pattern.

Risk management measures

Table 12 - ES2- Formulation of PM mixes

PROC	Concentration of MnS in PM mix	Concentration of MnS expressed as kg MnS/Tonne PM mix	Indoors/outdoors**	LEV (efficacy in %)	Respiratory protection (efficacy in %)	Dermal protection (efficacy in %)	duration	Inhalation exposure to MnS (mg/m^3) calculated by TRA	Derived inhalation exposure to Mn (mg/m^3)	Dermal exposure to MnS * (mg/kg/day) calculated by TRA	Derived dermal exposure to Mn, with gloves * (mg/kg/day)	Predicted EASE dermal exposure ((ug/cm2/dav)	Total systemic exposure (mg/kg/day)	Risk Characterisation Ratio (RCR) for sensitisation	Risk Characterisation Ratio (RCR) for systemic effects	Risk Characterisation Ratio (RCR) for inhalation
3	<1%	< 10	In-doors	No	No	No	> 4hr	0.1	0.06	0.07	3.42E-08	20	0.001	**0.17**	**0.32**	**0.32**
	1-5%	10-50	In-doors	90	No	80	> 4hr	0.02	0.01	0.03	1.37E-08	8	0.000	**0.07**	**0.06**	**0.06**
	5-25%	50-250	In-doors	90	No	80	> 4hr	0.06	0.04	0.08	4.11E-08	24	0.001	**0.20**	**0.19**	**0.19**
	>25 %	>250	In-doors	90	No	80	> 4hr	0.10	0.06	0.07	0	40	0.001	**0.34**	**0.32**	**0.32**
4	<1 %	< 10	In-doors	*90	No	No	> 4hr	0.08	0.05	0.69	1E-09	100	0.001	**0.85**	**0.24**	**0.24**
	1-5%	10-50	In-doors	*90	No	80	> 4hr	0.15	0.09	0.27	4E-10	40	0.002	**0.34**	**0.47**	**0.47**
	5-25%	50-250	In-doors	*90	90	90	>4 hr	0.15	0.09	0.82	1.2E-09	60	0.002	**0.51**	**0.47**	**0.47**
	> 25%	>250	In-doors	*90	90	90	>4 hr	0.18	0.11	0.69	1E-09	100	0.002	**0.85**	**0.55**	**0.55**
5	<1 %	< 10	In-doors	90	No	80	>4 hr	0.18	0.11	0.27	4E-10	40	0.002	**0.34**	**0.55**	**0.55**
	1-5%	10-50	In-doors	*90	90	80	>4 hr	0.02	0.01	0.55	8E-10	80	0.000	**0.68**	**0.05**	**0.05**
	5-25%	50-250	In-doors	*90	90	80	>4 hr	0.05	0.03	0.41	6E-10	60	0.001	**0.51**	**0.14**	**0.14**
	> 25%	>250	In-doors	*90	90	80	>4 hr	0.08	0.05	0.69	1E-09	100	0.001	**0.85**	**0.24**	**0.24**
8 b	100 %	Pure MnS	In-doors	95	90	90	> 4hr	0.13	0.08	1.37	6.85E-07	100	0.002	**0.85**	**0.40**	**0.40**
	100 %	Pure MnS	In-doors	95	90	90	1-4 hr	0.08	0.05	1.37	6.85E-07	100	0.001	**0.85**	**0.24**	**0.24**

* LEV and enhanced general ventilation
** No LEV and only 80% glove protection required, if charging of MnS to vessel is 1-4 hr duration

Waste related measures

Waste disposal should be according to relevant national/local legislations.

2.2 Exposure estimation

2.2.1 Workers exposure estimation

The long-term occupational exposures are calculated with the ECETOC TRA tool (ECETOC 2012), taking into account a high dustiness of the substance. PROC 3 (closed batch process), PROC 4 (process with opportunity for exposure), PROC 5 (mixing and blending), PROC 8b (transfer of MnS solid to vessel).

Table 13: ES2- Formulation of PM mixes

PROC	Concentration of MnS in PM mix	Indoors/outdoors**	LEV (efficacy in %)	Respiratory protection (efficacy in %)	Dermal protection (efficacy in %)	duration	Inhalation exposure to MnS (mg/m^3) calculated by TRA	Derived inhalation exposure to Mn (mg/m^3)	Dermal exposure to MnS * (mg/kg/day) calculated by TRA	Derived dermal exposure to Mn, with gloves * (mg/kg/day)	Predicted EASE dermal exposure (µg/cm2/day)	Total systemic exposure (mg/kg/day)
3	<1%	Indoors	No	No	No	> 4 hr	0.10	0.06	0.07	3.42E-08	20	0.001
	1-5%	Indoors	90	No	80	> 4 hr	0.02	0.01	0.03	1.37E-08	8	0.000
	5-25%	Indoors	90	No	80	> 4 hr	0.06	0.04	0.08	4.11E-08	24	0.001
	>25%	Indoors	90	No	80	> 4 hr	0.10	0.06	0.07	1.083E-07	40	0.001
4	<1%	Indoors	*90	No	No	> 4 hr	0.08	0.05	0.69	1E-09	100	0.001
	1-5%	Indoors	*90	No	80	> 4 hr	0.15	0.09	0.27	4E-10	40	0.002
	5-25%	Indoors	*90	90	90	> 4 hr	0.15	0.09	0.82	1.2E-09	60	0.002
	> 25%	Indoors	*90	90	90	> 4 hr	0.18	0.11	0.69	1E-09	100	0.002
5	<1%	Indoors	90	No	80	> 4 hr	0.18	0.11	0.27	4E-10	40	0.002
	1-5%	Indoors	*90	90	80	> 4 hr	0.02	0.01	0.55	8E-10	80	0.000
	5-25%	Indoors	*90	90	80	> 4 hr	0.05	0.03	0.41	6E-10	60	0.001
	> 25%	Indoors	*90	90	80	> 4 hr	0.08	0.05	0.69	1E-09	100	0.001
8b	100%	Indoors	95	90	90	> 4hr	0.13	0.08	1.37	6.85E-07	100	0.002
	100%	Indoors	95	90	90	1-4 hr	0.08	0.05	1.37	6.85E-07	100	0.001

* LEV and enhanced general ventilation
** No LEV and only 80% glove protection required, if charging of MnS to vessel is 1-4 hr duration

2.2.2 Consumer exposure

There is no consumer exposure to PM mixes.

2.2.3 Indirect exposure of humans via the environment (oral)

No significant exposure of humans via the environment is anticipated since MnS is not predicted to accumulate or be transferred to animal tissues and nor is it expected to reach significant levels in groundwater.

3 Compaction /sintering of PM mixes

3.1 ES 3: Compaction /sintering of PM mixes (IU2) (ES 3) (SU 3; PROC 14, 22, 8b; PC 7; AC not applicable) – IU2

Description of activities and processes covered in the exposure scenario

For IU2, the PM mixes will be compacted (**PROC 14**) using high pressure at a temperature between RT-150°C then sintered at high temperature. Exposure is assumed during addition of PM mix to a compaction 'mould' (**PROC 22**). Exposure can also arise when the PM mix (usually containing max 0.3% MnS) is transferred from the big-bag to the press hopper (**PROC 8b**). The scenario is also expanded to assess exposure to higher concentrations of MnS if this is required. The sintering process is assumed to operate at temperatures below the melting point of MnS. The scenario is also expanded to assess exposure to higher concentrations of MnS if this is required.

Operational conditions

Normal working days up to 365 days per year for up to 24 hours a day. It is expected that transfer of PM mix takes significantly less than a working shift of 8 hours per day.

Risk management measures

Table 22: ES3- Compaction /sintering of PM mixes

PROC	Concentration of MnS in PM mix	Concentration of MnS expressed as kg MnS/Tonne	Indoors/ outdoors*	LEV (efficacy in %)	Respiratory protection (efficacy in %)	Dermal protection (efficacy in %)	duration	Inhalation exposure to Mn S (mg/m^3) calculated by TRA	Derived inhalation exposure to Mn (mg/m^3)	Dermal exposure to MnS *? (mg/kg/day) calculated by	Derived dermal exposure to Mn, with gloves (mg/kg/day)	Predicted EASE dermal exposure ((ug/cm2/day)	Total systemic exposure (mg/kg/day)	Risk Characterisation Ratio (RCR) for sensitisation	Risk Characterisation Ratio (RCR) for systemic effects	Risk Characterisation Ratio (RCR) for inhalation
14	<1%	< 10	Indoor	no	no	no	> 4hr	0.01	0.01	0.34	1.71 E-07	50	0.0001	**0.43**	**0.03**	**0.03**
	1-5%	10-50	Indoor	no	no	80	> 4hr	0.02	0.01	0.14	6.85 E-08	20	0.0003	**0.17**	**0.06**	**0.06**
	5-25%	50-250	Indoor	no	no	80	> 4hr	0.06	0.04	0.41	2.06 E-07	60	0.0008	**0.51**	**0.19**	**0.19**
	>25%	>250	Indoor	no	no	80	> 4hr	0.10	0.06	0.69	3.42 E-07	100	0.0013	**0.85**	**0.32**	**0.32**
22a	<1%Mn	< 10	Indoor	no	no	no	> 4hr	0.10	0.06	0.28	1.41 E-07	10	0.0013	**0.09**	**0.32**	**0.32**
	1-5%	10-50	Indoor	no	no	80	> 4hr	0.20	0.13	0.11	5.64 E-08	4	0.0026	**0.03**	**0.63**	**0.63**
	5-25%	50-250	Indoor	90	no	80	> 4hr	0.06	0.04	0.21	1.70 E-07	60	0.0008	**0.51**	**0.19**	**0.19**
	>25%	>250	Indoor	90	no	80	> 4hr	0.10	0.06	2.83	2.82 E-07	100	0.0013	**0.85**	**0.32**	**0.32**
8b	<1%	< 10	Indoor	95	no	no	> 4hr	0.13	0.08	1.37	6.85 E-07	100.	0.0016	**0.85**	**0.40**	**0.40**
	1-5%	10-50	Indoor with LEV and enhanced general ventilation	95	no	90	> 4hr	0.08	0.05	0.27	1.37 E-07	20	0.0010	**0.17**	**0.24**	**0.24**
	5-25%	50-250	Indoor	95	90	90	> 4hr	0.08	0.05	0.82	4.11 E-07	60	0.001	**0.51**	**0.24**	**0.24**
	>25%	>250	Indoor	95	90	95	> 4hr	0.13	0.08	0.69	3.42 E-07	50	0.002	**0.43**	**0.40**	**0.40**
	<1%	< 10	Indoor	95	no	no	1-4 hr	0.08	0.05	1.37	6.85 E-07	100.	0.000	**0.85**	**0.12**	**0.24**

PROC	Concentration of MnS in PM mix	Concentration of MnS expressed as kg MnS/Tonne	Indoors/ outdoors*	LEV (efficacy in %)	Respiratory protection (efficacy in %)	Dermal protection (efficacy in %)	duration	Inhalation exposure to Mn S (mg/m^3) calculated by TRA	Derived inhalation exposure to Mn (mg/m^3)	Dermal exposure to MnS *? (mg/kg/day) calculated by	Derived dermal exposure to Mn, with gloves (mg/kg/day)	Predicted EASE dermal exposure ((µg/cm2/day)	Total systemic exposure (mg/kg/day)	Risk Characterisation Ratio (RCR) for sensitisation	Risk Characterisation Ratio (RCR) for systemic effects	Risk Characterisation Ratio (RCR) for inhalation
	1-5%	10-50	Indoor	95	no	80	1-4 hr	0.15	0.09	0.55	2.74 E-07	40	0.001	**0.34**	**0.24**	**0.47**
	5-25%	50-250	Indoor with LEV and enhanced general ventilation	95	no	90	1-4 hr	0.14	0.09	0.82	4.11 E-07	60	0.001	**0.51**	**0.21**	**0.43**
	>25%	>250	Indoor with LEV and enhanced general ventilation	95	no	90	1-4 hr	0.23	0.14	1.37	6.85 E-07	100	0.001	**0.85**	**0.36**	**0.71**

* LEV and enhanced general ventilation

Waste related measures

Waste disposal should be conducted in accordance with national/local legislations.

3.2 Exposure estimation

3.2.1 Workers exposure estimation

The workers may experience inhalation exposure to dusts during the transfer of PM mix to compaction moulds. No measured long-term occupational exposure concentrations are available. The long-term occupational exposure concentrations are calculated with the ECETOC TRA tool (ECETOC 2012), taking into account a high dustiness of the substance. To cover the transfer at dedicated facilities and the use of large and small containers, PROC 8b (dedicated facilities, large containers) is used to calculate the exposure concentrations. To cover exposure during compaction, and sintering, PROC 14 and 22 respectively, are used.

Table 23: ES 3- Exposure to PM mix containing MnS

PROC	Concentration of MnS in PM mix	Indoors/ outdoors*	LEV (efficacy in %)	Respiratory protection (efficacy in %)	Dermal protection (efficacy in %)	duration	Inhalation exposure to Mn S (mg/m^3) calculated by TRA	Derived inhalation exposure to Mn (mg/m^3)	Dermal exposure to MnS *(mg/kg/day) calculated by TRA	Derived dermal exposure to Mn, with gloves (mg/kg/day)	Predicted EASE dermal exposure ((µg/cm2/day)	Total systemic exposure (mg/kg/day)
14	<1%	Indoor	no	no	no	> 4hr	0.01	0.01	0.34	1.71E-07	50	0.0001
	1-5%	Indoor	no	no	80	> 4hr	0.02	0.01	0.14	6.85E-08	20	0.0003
	5-25%	Indoor	no	no	80	> 4hr	0.06	0.04	0.41	2.06E-07	60	0.0008
	>25%	Indoor	no	no	80	> 4hr	0.10	0.06	0.69	3.42E-07	100	0.0013
22a	<1% Mn	Indoor	no	no	no	> 4hr	0.10	0.06	0.28	1.41E-07	10	0.0013
	1-5%	Indoor	no	no	80	> 4hr	0.20	0.13	0.11	5.64E-08	4	0.0026
	5-25%	Indoor	90	no	no	> 4hr	0.06	0.04	1.70	8.48E-07	60	0.0008
	>25%	Indoor	90	no	no	> 4hr	0.10	0.06	2.83	1.41E-06	100	0.0013
8b	<1%	Indoor	95	no	no	> 4hr	0.13	0.08	1.37	6.85E-07	100.	0.0016
	1-5%	Indoor with LEV and enhanced general ventilation	95	no	90	> 4hr	0.08	0.05	0.27	1.37E-07	20	0.0010
	5-25%	Indoor	95	90	90	> 4hr	0.08	0.05	0.82	4.11E-07	60	0.0010
	>25%	Indoor	95	90	95	> 4hr	0.13	0.08	0.69	3.42E-07	50	0.0016
	<1%	Indoor	95	no	no	1-4 hr	0.08	0.05	1.37	6.85E-07	100	0.0005
	1-5%	Indoor	95	no	80	1-4 hr	0.15	0.09	0.55	2.74E-07	40	0.0010
	5-25%	Indoor with LEV and enhanced general ventilation	95	no	90	1-4 hr	0.14	0.09	0.82	4.11E-07	60	0.0009
	>25%	Indoor with LEV and enhanced general ventilation	95	no	90	1-4 hr	0.23	0.14	1.37	6.85E-07	100	0.0015

* LEV and enhanced general ventilation

3.2.2 Consumer exposure

There will be no consumer exposure from the uses described in this scenario.

3.2.3 Indirect exposure of humans via the environment (oral)

No significant exposure of humans via the environment is anticipated since MnS is not predicted to accumulate or be transferred to animal tissues and nor is it expected to reach significant levels in groundwater.

4 Machining of compacted/ sintered PM component into final articles

4.1 ES 4: Machining of compacted/ sintered PM component into final articles (SU 15; PROC 21, 24; PC not applicable; AC 12, 7) – IU 3

Description of activities and processes covered in the exposure scenario

For IU3, the compacted/sintered component is machined into an article which will have a service-life (most likely in the automotive industry and gears in hand tools) and a waste stage. It is assumed that exposure can occur during machining to make the article (**PROC 21, 24**) and that this machining can be either a low energy (**PROC 21)** or high energy **(PROC 24)** mechanical process. The scenario is also expanded to assess exposure to higher concentrations of MnS if this is required.

Operational conditions

Activities can occur up to 365 days a year, up to 24 hr a day with shifts of 8 hrs.

Risk management measures

Table 32: ES 4- Exposure to MnS contained in alloys

PROC	Concentration of MnS in PM mix	Indoors/ Outdoors*	LEV (efficacy in %)	Respiratory protection (efficacy in %)	Dermal protection (efficacy in %)	duration	Inhalation exposure to MnS (mg/m^3) calculated by TRA	Derived inhalation exposure to Mn (mg/m^3)	Dermal exposure to MnS * (mg/kg/day) calculated by TRA	Derived dermal exposure to Mn, with gloves (mg/kg/day)	Predicted EASE dermal exposure ((µg/cm2/day)	Total systemic exposure (mg/kg/day)	Risk Characterisation Ratio (RCR) for sensitisation	Risk Characterisation Ratio (RCR) for systemic effects	Risk Characterisation Ratio (RCR) for inhalation
21	<1%	In-doors	No	no	No	> 4hr	0.30	0.19	0.28	0.18	10	0.004	**0.09**	**0.95**	**0.95**
	1-5%	In-doors	**90**	no	**80**	> 4h	0.12						**0.03**	**0.38**	**0.38**
	5-25%	In-doors	**90**	**90**	**80**	> 4h	0.36	0.08	0.11	0.07	4	0.002	**0.10**	**0.18**	**0.18**
	> 25%	In-doors	**90**	**90**	**80**	> 4h	0.60	0.04	0.34	0.22	12	0.001	**0.17**	**0.30**	**0.30**
24	<1%	In-doors	No	No	No	> 4h	0.08	0.06	0.57	0.36	20	0.001	**0.09**	**0.95**	**0.95**
	1-5%	In-doors	**90**	No	**80**	> 4h	0.15	0.19	0.28	0.18	10	0.004	**0.03**	**0.47**	**0.47**
	5-25%	In-doors	**90**	**90**	**80**	> 4h	0.05	0.10	0.11	0.07	4	0.002	**0.10**	**0.14**	**0.14**
	>25 %	In-doors	**90**	**90**	**80**	> 4h	0.08	0.03	0.34	0.22	12	0.001	**0.17**	**0.24**	**0.24**

* LEV and enhanced general ventilation

Waste related measures

Waste disposal should be conducted in accordance with national/local legislations.

4.2 Exposure estimation

4.2.1 Workers exposure estimation

The machining that is carried out is mainly drilling but also cutting and some grinding can be done. PROC 21 and PROC24 were used in ECETOC using **low** dustiness. The following exposures are indicated in the table below:

Table 33: ES 4- Exposure to MnS inside alloys when machining

PROC	Concentration of MnS in PM mix	Indoors/ outdoors**	LEV (efficacy in %)	Respiratory protection (efficacy in %)	Dermal protection (efficacy in %)	duration	Inhalation exposure to MnS (mg/m^3) calculated by TRA	Derived inhalation exposure to Mn (mg/m^3)	Dermal exposure to MnS * (mg/kg/day) calculated by TRA	Derived dermal exposure to Mn, with gloves (mg/kg/day)	Predicted EASE dermal exposure (µg/cm2/day)	Total systemic exposure (mg/kg/day)
21	<1%	Indoors	No	no	No	>4 hr	0.3	0.19	0.28	0.18	10	0.004
	1-5%	Indoors	90	no	80	>4 hr	0.12	0.08	0.11	0.07	4	0.002
	5-25%	Indoors	90	90	80	>4 hr	0.36	0.04	0.34	0.21	12	0.001
	> 25%	Indoors	90	90	80	>4 hr	0.6	0.06	0.57	0.36	20	0.001
24	<1%	Indoors	No	No	No	>4 hr	0.075	0.19	0.28	0.18	10	0.004
	1-5%	Indoors	90	No	80	>4 hr	0.15	0.09	0.11	0.07	4	0.002
	5-25%	Indoors	90	90	80	>4 hr	0.045	0.03	0.34	0.21	12	0.001
	>25%	Indoors	90	90	80	>4 hr	0.075	0.05	0.57	0.36	20	0.001

* LEV and enhanced general ventilation
** No LEV and only 80% glove protection required, if charging of MnS to vessel is 1-4 hr duration

4.2.2 Consumer exposure

Consumer machining of alloys containing MnS is not expected.

Service life

Leaching of MnS from articles is likely to be negligible. Possible consumer contact with the article may occur, but the duration exposure to such articles is considered to be negligible and highly infrequent. Taken together, it is considered that no further assessment is necessary.

4.2.3 Indirect exposure of humans via the environment (oral)

No significant exposure of humans via the environment is anticipated since MnS is not predicted to accumulate or be transferred to animal tissues and nor is it expected to reach significant levels in groundwater.

5 Use of machined article in industry e.g. automotive industry

5.1 ES 5: Use of machined article in industry e.g. automotive industry (SU 3, 21, 22; PROC 21, ERC 6a) – IU 4

Description of activities and processes covered in the exposure scenario

For IU4, this is simply handling of metal articles (**PROC 21**)

Operational conditions

The articles may be used up to 365 days per year, up to 24 hours per day and 8 hr shifts.

Risk Mitigation

It is not considered that risk mitigation from exposure to MnS is required for this identified use.

Waste related measures

Waste disposal should be conducted in accordance with national/local legislations.

5.2 Exposure estimation

5.2.1 Workers exposure

Exposure in this identified use is likely to be negligible due to normal handling of a machined article. Leaching of MnS from the alloyed articles is likely to be negligible, with actual contact being infrequent. It is possible that the scenario in ES4 for PROC 21 can cover this, but the RMM required would be lower.

5.2.2 Consumer exposure

No consumer exposure to manganese sulphide from handling any articles containing MnS is anticipated.

Service life

Leaching of MnS from articles is likely to be negligible. Possible consumer contact with the article may occur, but the duration exposure to such articles is considered to be negligible and highly infrequent. Taken together, it is considered that no further assessment is necessary.

5.2.3 Indirect exposure of humans via the environment (oral)

No significant exposure of humans via the environment is anticipated since MnS is not predicted to accumulate or be transferred to animal tissues and nor is it expected to reach significant levels in groundwater.