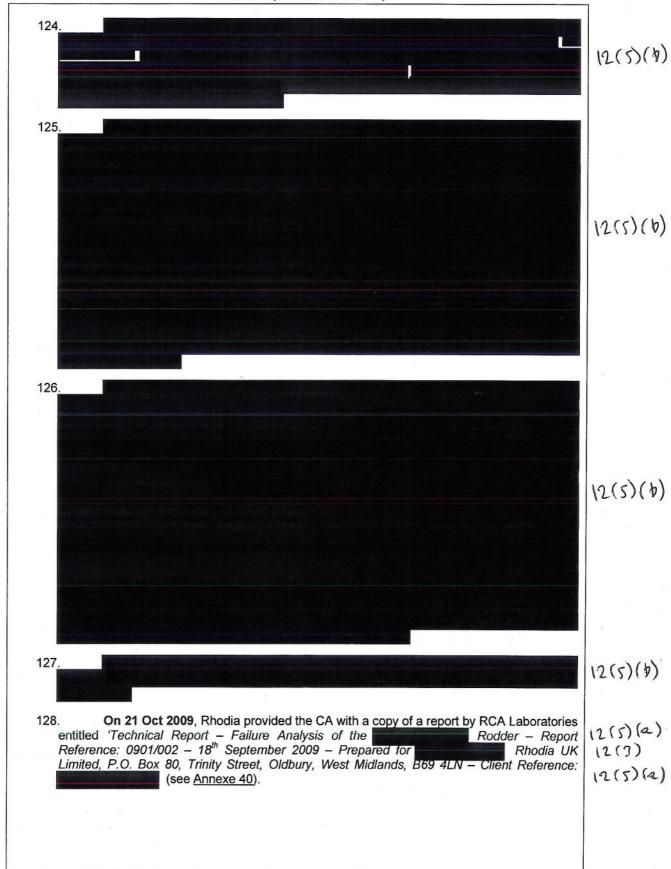
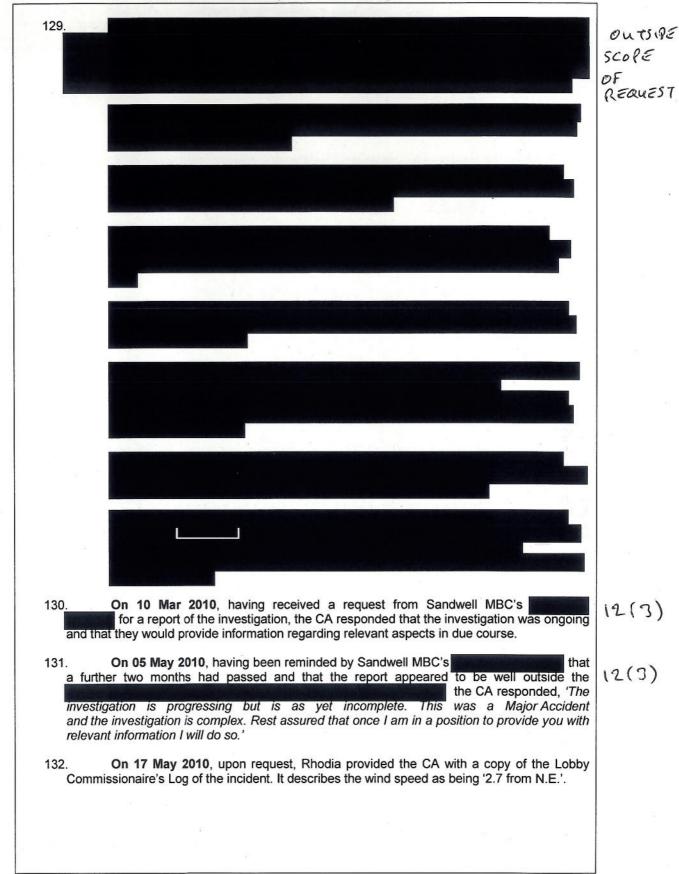
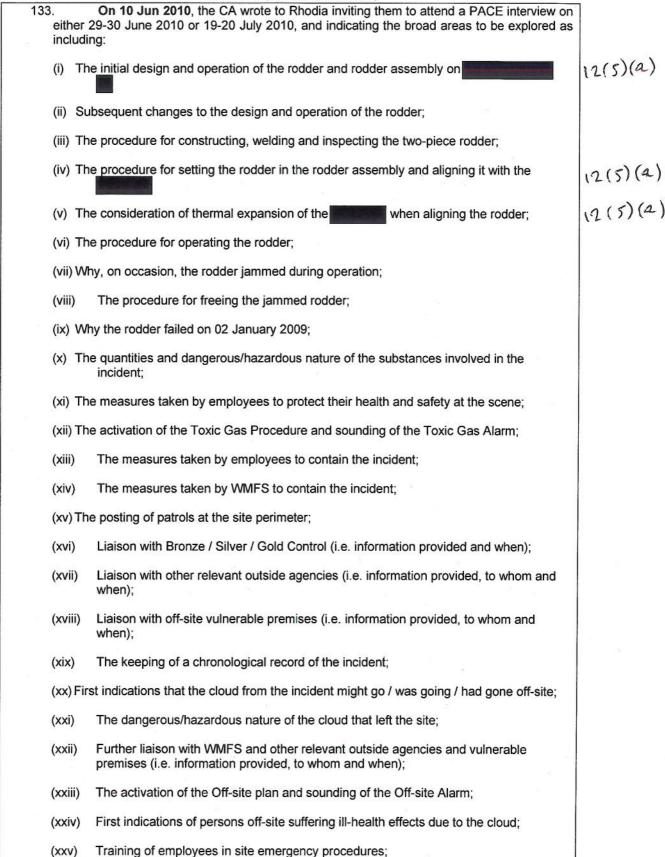
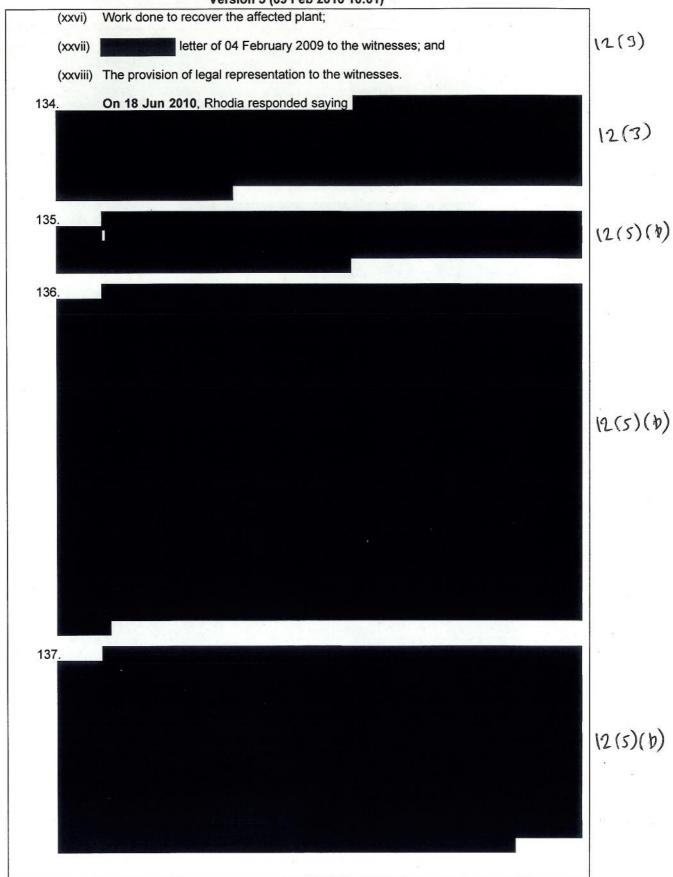


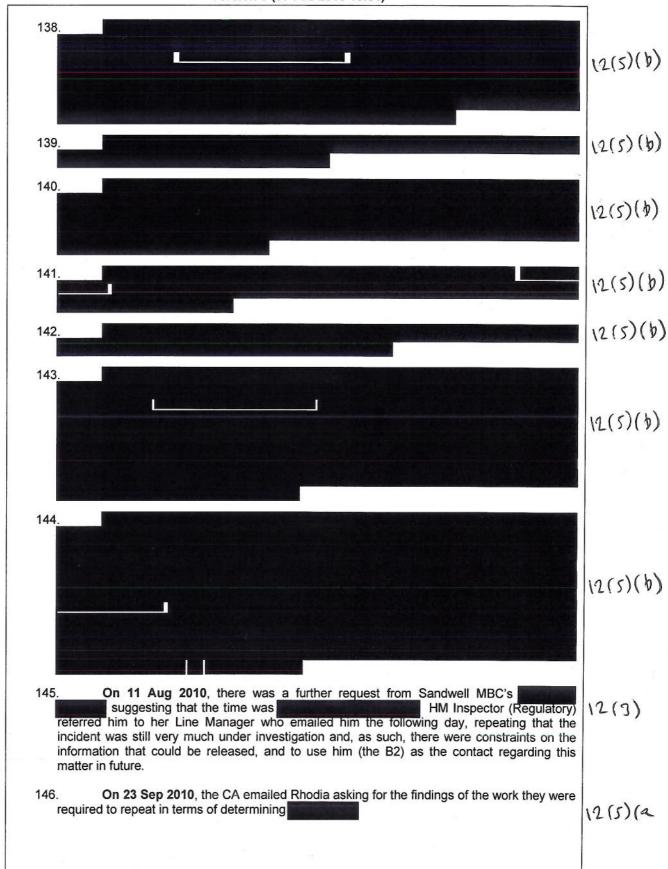
provide AVT's findings from the work.

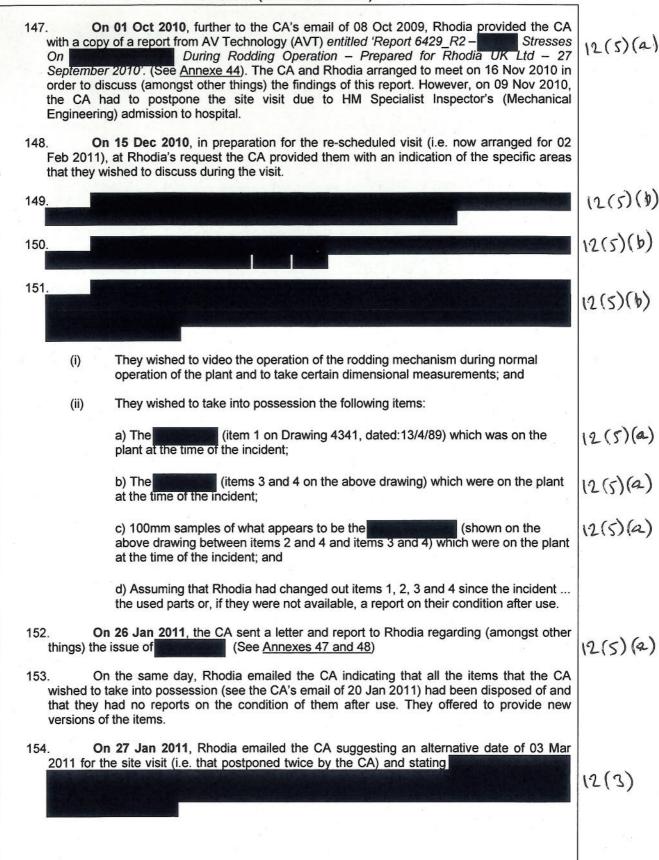


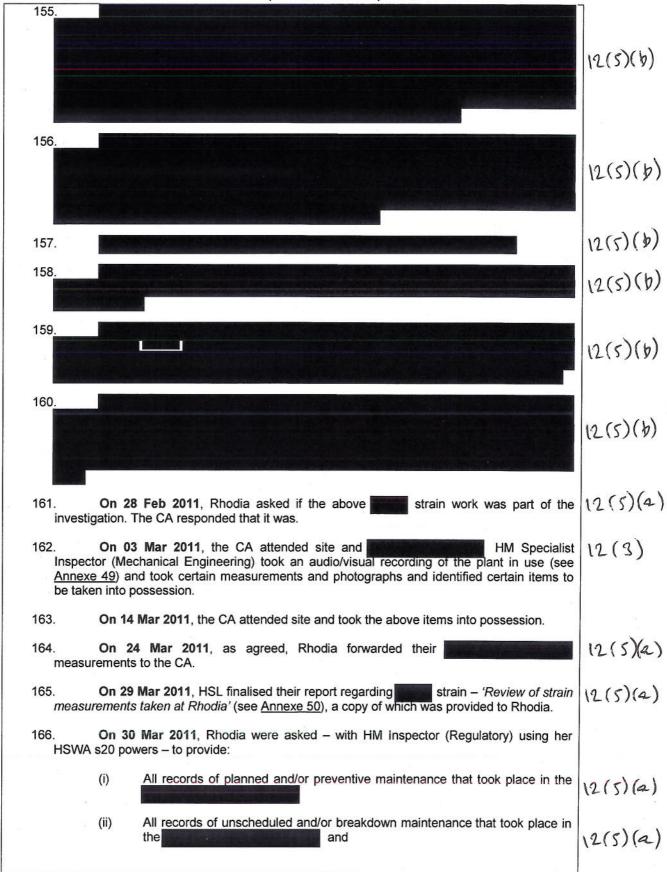


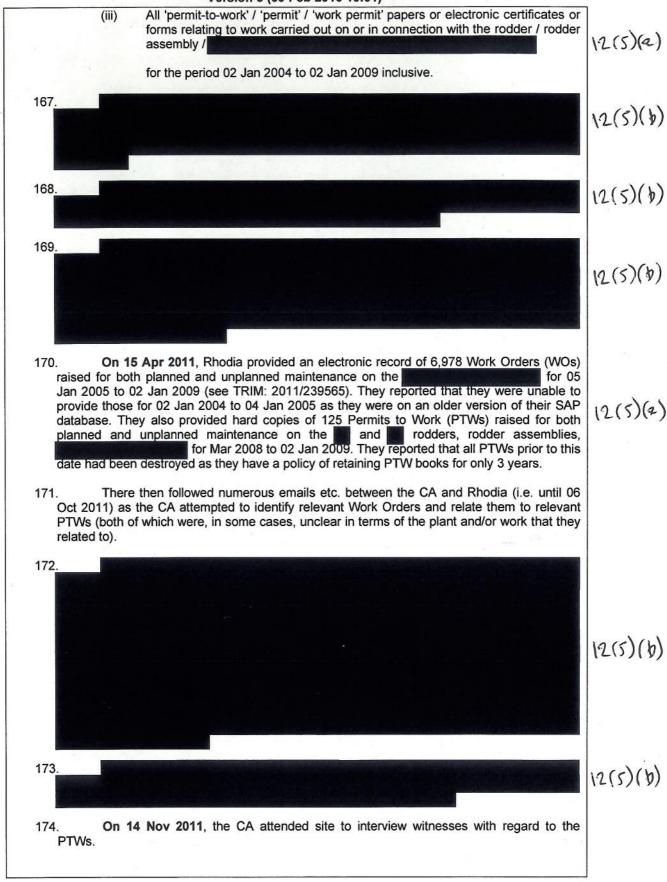


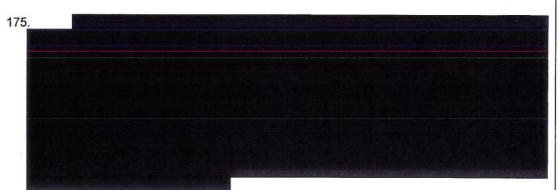












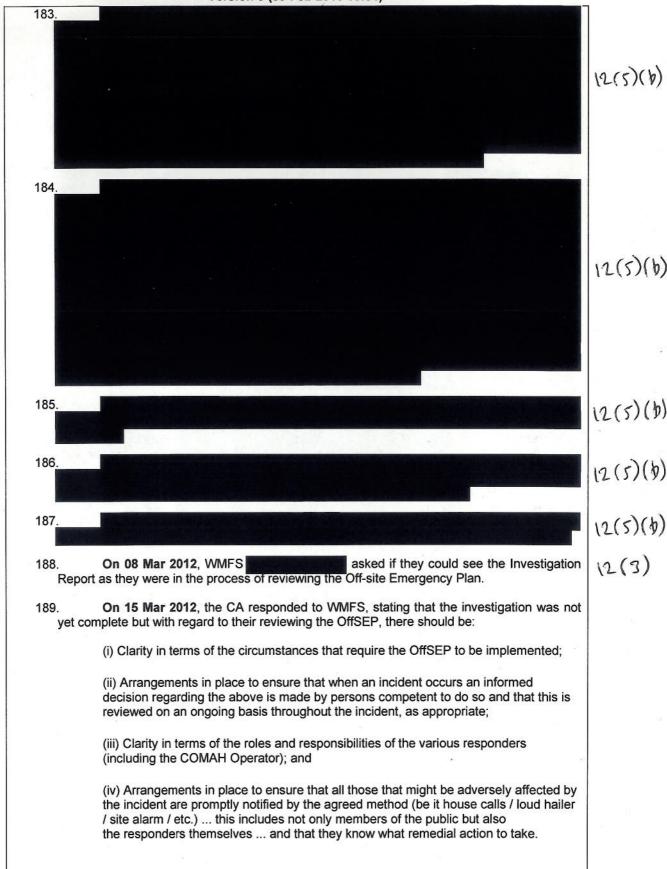
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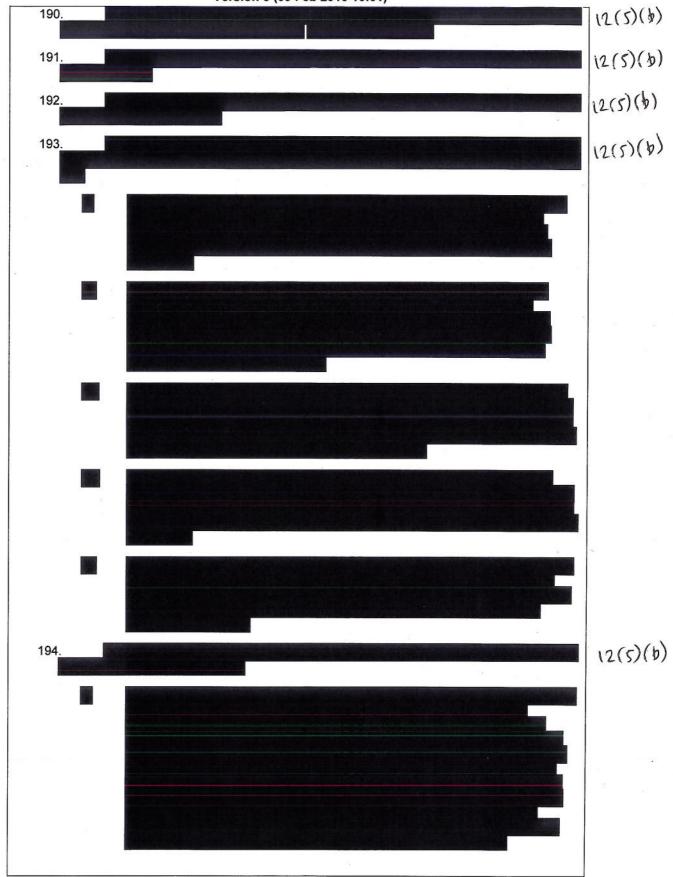
176. On the same day, the CA emailed Rhodia asking them to provide copies of all PTWs relating to the investigation/freeing/release of a jammed/stuck rodder on both for the period from the date of the incident of 02 Jan 2009 to the date of the planned plant shut-down in Sep 2011 (i.e. a period of 2 years 9 months). The CA also asked Rhodia to provide a copy of the written procedure for installing and aligning the rodder on (which was drawn-up and put in place following the incident) and to confirm the date that the procedure was put in place.

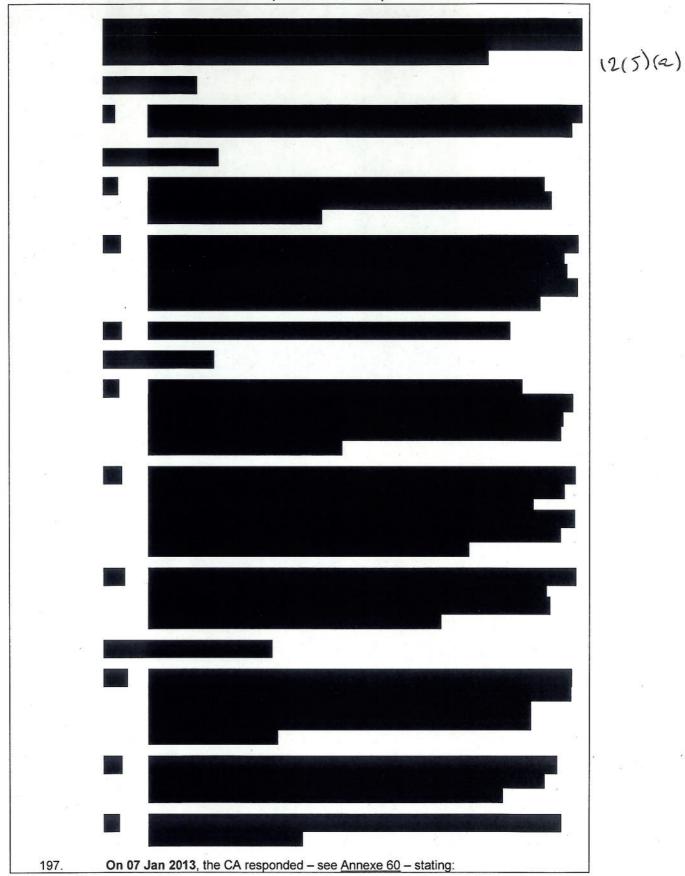
12(5)(a)

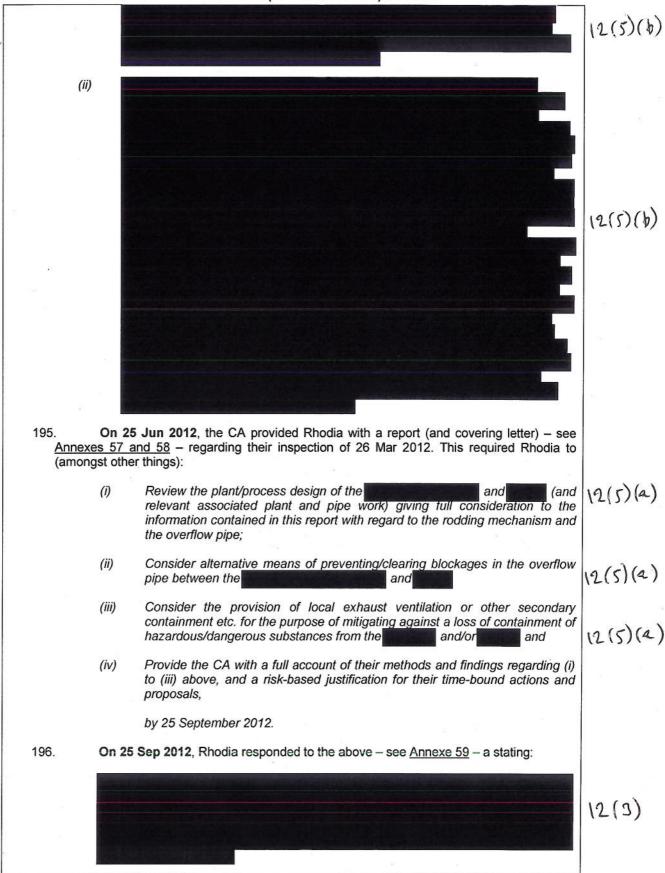
- 177. On 17 Nov 2011, as requested, Rhodia provided a copy of their post-incident procedure for the alignment of the rodder and confirmed that it was drafted and used in the first shutdown following the incident (i.e. Sep 2009) and was reviewed and finalised on 09 Jul 2010 See Annexe 51.
- 178. On 21 Nov 2011, the CA responded to Rhodia's query of 15 Nov 2011 regarding offsite persons affected by the incident, stating that they were not at liberty to provide Rhodia with individuals' names or details at this time, but thanking them for the offer of the services of their company Doctor and information regarding the chemicals.
- 179. On 23 November 2011, in response to the CA's request of 15 Nov 2011, Rhodia emailed just three PTWs: (see TRIM: 2011/609114) for the period from the incident of 02 Jan 2009 to the planned shut-down in Sep 2011.
- 180. On 01 Dec 2011, with regard to off-site persons affected by the incident, Rhodia asked if it would be possible for the CA to provide generic information such as confirming whether people were affected, the number of people affected, their position in relation to the site at the time of the incident and the symptoms they reported.
- 181. On 05 Dec 2011, the CA responded that, until such time as they reached the stage of the investigation where they were able to provide more specific detail, they would advise Rhodia that witnesses report having been in the vicinity of either: J2 of the M5; Titford Road; or ASDA at the time of the incident and they report that they were contacted by substances leaving the site during the incident and that they subsequently sought medical attention for symptoms consistent with their having been exposed to substances hazardous to health.
- 182. On 21 Dec 2011 Rhodia sent the CA a lengthy email with regard to the issue of offsite persons affected by the incident. They stressed that they had not requested individuals' personal details (... but they had, i.e. in their email of 15 Nov 2011 they asked,

12(3)

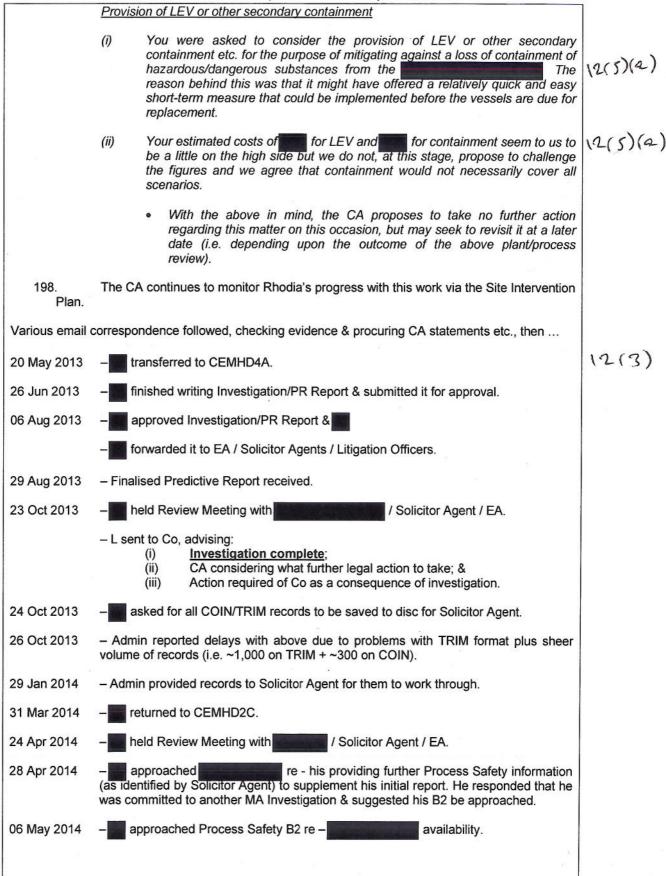






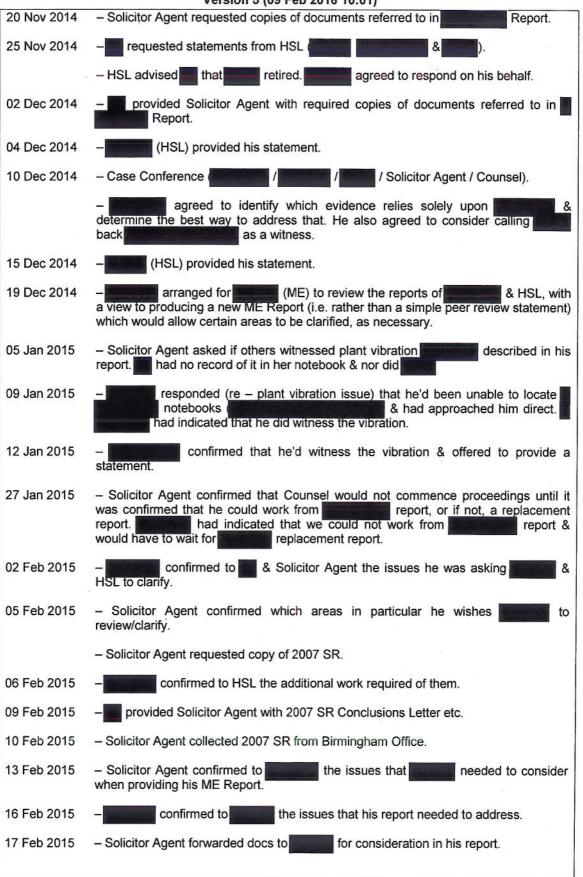


Alter	mative means of preventing/clearing blockages in the overflow pipe between the (i.e. in the current configuration)	12(5)(a)
<i>(i)</i>	We note your response regarding either not rodding at all, or else providing alternative means of clearing the overflow pipe between the and the	12(5)(2)
(ii)	We are inclined to agree with you that neither of the options put forward would appear to be viable for the plant in its current configuration. You thus appear to be left with little alternative but to review the design of the and the (and associated plant and pipe work), as you were asked to do (see below).	(2(5)(2)
	iewing the design of the associated plant and work) (and associated plant	(2(5)(2)
(i)	We note your response that it may be possible to prevent blockages in the overflow pipe between the and the by significantly increasing its diameter and your conclusion that, based upon cost, such work would not be reasonably practicable.	12(5)(2)
(ii)	In this action we were not, in fact, asking you to maintain a means of clearing the overflow pipe in its current configuration, rather we were asking you to reconsider and review the overall design of the the and relevant associated plant and pipe work, for the purpose of either eliminating the risk of loss of containment from this current potential weak point or else reducing the risk to ALARP.	12(5)(a)
(iii)	Re-designing the and associated plant and pipe work would undoubtedly be costly and may indeed exceed the sum of suggested by you as being justifiable. However, the are replaced at relatively short intervals (i.e. every 2yrs) so the figure you suggest would appear to be somewhat spurious, i.e. the actual cost of the project would be the cost of the etc. (and, perhaps, supporting metal framework) plus the design costs themselves, rather than the entire replacement. This is, of course, for you (as the Operator) to explore, but we are of the opinion that you have not given this matter sufficient consideration and would currently struggle to make your ALARP demonstration.	12(5)(2)
(iv)	With regard to your reporting that rodders are in use on all around the world; if this is the case then the use of rodders may well be deemed 'industry practise' but it does not necessarily qualify it as being 'Industry Best Practise'. Either way, the issue here is not whether rodders are in use elsewhere, but whether you can demonstrate ALARP for their use at your establishment.	12(5)(2)
	Giving full consideration to the information and guidance contained in both this letter and all previous relevant correspondence, you should continue with your review of the plant/process design of the and (and relevant associated plant and pipe work) for the purpose of identifying an alternative, more suitable design that either eliminates or reduces the risk of loss of containment of COMAH dangerous substances from this part of the plant to ALARP. Upon completion of your review, you should provide information to the CA by which to make your ALARP demonstration. (COMAH Regulation 4 – By 08 April 2013)	12(5)(2)
	(* On	

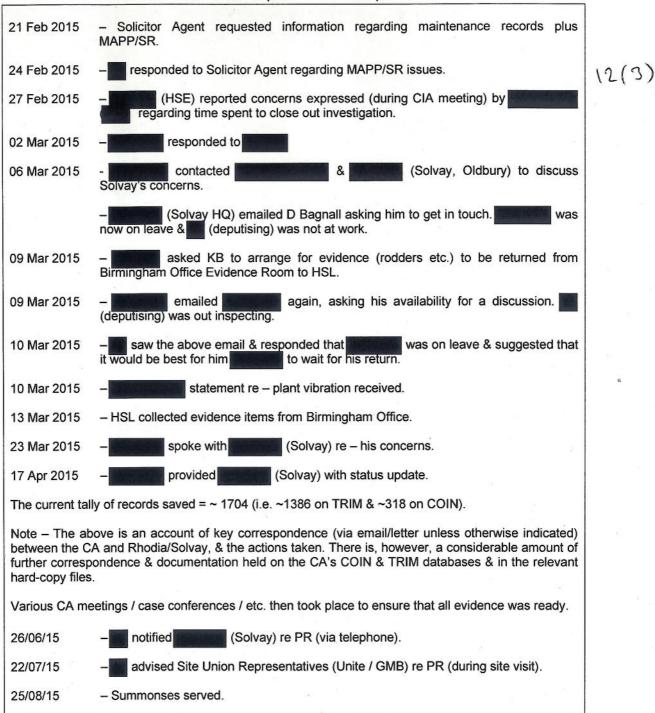


	Version 5 (09 Feb 2016 10:01)
30 Apr 2014	 EA reported that a colleague (SA requested further details.
06 May 2014	- Process Safety B2 indicated that unavailable.
07 May 2014	- Finalised ME Statement received.
08 May 2014	- Further Drawing (referenced in their docs) requested from Co.
	approached Process Safety B1 re - unavailability.
12 May 2014	 Highway's Agency & West Midlands Police approached for material obtained during their investigation. Highway's Agency returned nil response.
13 May 2014	- Process Safety B1 responded that not available, but he would find alternative.
15 May 2014	 EA advised that colleague (expenses to the colleague) unable to locate diary for time in question so unable to provide evidence.
02 Jun 2014	- Process Safety B1 offered as alternative to
	- provided questions to
16 Jun 2014	indicated unable to respond until mid- to late-July.
01 Aug 2014	 Co changed name to Solvay Solutions UK Ltd.
04 Aug 2014	 Site intervention re – E- preparedness/response (in accordance with plan).
05 Aug 2014	 West Midlands Police provided copy of their log for day of incident.
12 Aug 2014	 A Cox provided response re – PS issues.
20 Aug 2014	 Solicitor Agent finalised briefing for Counsel.
16 Sep 2014	- (ME) taken ill (i.e. approximate date).
25 Sep 2014	- Solicitor Agent met with Counsel.
30 Sep 2014	
10 Oct 2014	 Meeting between Solicitor Agent & to discuss conversion of latter's statement to a report + a covering statement.
31 Oct 2014	Case Conference [EA] / Solicitor Agent / Counsel). Counsel indicated a wish to discuss certain ME issues with
06 Nov 2014	- (ME B2) agreed to respond to any questions on behalf of
12 Nov 2014	provided copies of relevant reports etc. to
13 Nov 2014	provided required report & statement.
17 Nov 2014	approached HSL for copies of their correspondence with
18 Nov 2014	- HSL provided required information & forwarded it to

12(3)



12(3)



Safety Management System (SMS)

COMAH Safety Report 2007

Plant description and controls

 The Safety Report (SR) provides an overview of the plant and processes involved, including reference to the rodder and the frequency of rodding, although the latter is contradictory, i.e. as previously described: on page 178 it states that rodding is done hourly; whilst on page 191 it states that it is done every two hours.

Consequences of a release

 The likely consequences of a phosphine release are described in the SR. Indeed Rhodia (in their Voluntary Statement) direct the CA to pages 476 and 496 of the SR and state

(2(5)(2)

3. However, in their Plant Emergency Dossier, March 2005, page 7, paragraph 1.4.9, it states

12(5)(2)

HAZOP

Rodder failure

- The 1980 HAZOP (i.e. current at the time of the incident) did not consider the failure of the rodder.
- 5. The post-incident HAZOP, however, does, i.e. it describes the 'Deviation' as and the 'Consequence' as and, interestingly, 'No HSE issue', with the 'Cause' being, and the 'Existing Barriers/Actions' being,

 See Annexe 33 for both HAZOPs.

12(3)

- 6. Rhodia state that:
 - (i) Both the 1980 [i.e. current at the time of the incident] and the current [i.e. post-incident] HAZOP dealt with the risk of the rodder sticking as a production issue, but did not deal with catastrophic failure of the rodder because this was unforeseeable;
 - (ii) The 1980 HAZOP does not highlight straightness/distortion as a potential deviation, so the Company could not reasonably have known that the impact of the rodder not being perfectly straight would have led to it failing;

- (iii) There had never been any suggestion that minor stresses and strains could cause a rotating bend failure, and that given that rotating bend failure was unforeseeable it could not have been guarded against as this would have required them to first foresee it;
- (iv) The rodder failed not due to jamming/sticking but because it was not precisely straight when manufactured, leading to rotating bending fatigue, and the risk of failure occurring from rotational stresses was not identified in the HAZOP because it was unforeseeable;
- (v) Immediately after the incident, no-one (including the HSE's Mechanical Engineering Specialist Inspector) could understand how the rodder bar had failed. After completion of the metallurgical studies on the failed rodder (commissioned by the Company) the HSE's Mechanical Engineering Specialist Inspector informed the Company that, until that point, the HSE had "been scratching their heads on this". He stated that they could not see how sufficient force could be imparted to the rodder to break it at the joint. Clearly even following the incident its cause had not been foreseeable, let alone prior to its occurrence.

7. From this it would appear that:

- (i) They were aware, prior to the incident, that the rodder stuck (although this is not implicit in the 1980 HAZOP);
- (ii) They are confused as to the purpose of a HAZOP in terms of identifying foreseeable deviations; and
- (iii) They are of the opinion that if the cause of failure is not immediately apparent to the CA, then it cannot have been foreseeable.

Blockage of isolation valve

- 8. Neither the 1980 nor the post-incident HAZOP appear to consider the blockage of the isolation valve (in the blockage of the isolation by the rodder.
- 9. Employees were unable to close the isolation valve between the and the due to the position of the broken rodder. When asked whether this scenario had been considered previously, for example during the HAZOP, Rhodia stated that rotating bend failure had not been foreseen and that whilst the HAZOP dealt with the risk of the rodder sticking as a production issue, it did not deal with catastrophic failure of the rodder because this was unforeseeable.
- 10. Rhodia holds no documentary evidence of the scenario of a broken rodder blocking the isolation valve having been considered previously.
- 11. The issue of isolation is one that is now being progressed via the CA's Intervention Plan.

Design / Management of Change / Design Review

12. Rhodia state that:

- (i) The rodder was a bespoke design and no recognised standards were available for such devices in 1989, so it was designed to good engineering practice standards and the adequacy of the design was assessed by A&W's Technical Development Department;
- (ii) Whilst they are sure that the changes from manual to pneumatic, and from a

12(5)(a)

12(5)(2)

one-piece to a two-piece rodder, would have been assessed via A&W's Management of Change process, these changes occurred in the 1980s and there were no arrangements in place to ensure retention of records to present day, so they are unable to provide records of any management of change assessments carried out. However, the failure of the rodder arose because the rod was not precisely straight when manufactured, and the 1980 HAZOP does not highlight straightness/distortion as a potential deviation, so they could not reasonably have known that the impact of the rodder not being perfectly straight would have led to it failing. Therefore it cannot reasonably be expected that any management of change risk assessment (whether relating to the change from manual to pneumatic operation, or to the change from a one piece to two piece rodder) would have identified this risk; and

- (iii) In the intervening years (i.e. since these changes and since they took over the site), in terms of design review (i.e. for the purpose of comparing the design of the rodder and rodder assembly with up-to-date design principles and considering the measures that need to be taken in order to reduce the risk to ALARP) the adequacy of plant design has been assessed every five years via their COMAH report and their SRD (HAZOP) Studies, copies of the most recent versions of which were sent to the CA (i.e. COMAH Safety Report on 02 April 2012 and the HAZOP on 31 March 2009). However, it was not reasonably foreseeable that the impact of the rodder not being perfectly straight would have led to it failing. On that basis reviews of plant design prior to the incident could not be expected to highlight this causative issue.
- 13. As previously described, the purpose of the rodder is to remove deposits of that collect in the but when asked how they calculated or otherwise determined the required strength of the rodder to undertake this task, Rhodia responded that the required strength of the rodder to undertake the removal of deposits in the has no relevance to the incident.

12(5)(2)

Maintenance

14. As previously described, there are Plant Meetings held in the a week (i.e. on Monday, Wednesday and Friday) when issues of importance relating to production and maintenance on the plant are discussed. Attendees include the the Plant Supervisor, the Process Engineer, the Electrical/Instrumentation Engineer, but not all would necessarily be present all of the time. The reports that the problem of jamming or sticking of the rodders would have been brought up at these meetings.

12(5)(a)

12(3)

12(3)

15. Rhodia report that:

- To the best of their knowledge the rodder involved in the incident had never become sticky and had never been turned by a spanner;
- (ii) They monitor downtime and causes on the

12(5)(2)

- (iii) They audit a wide range of Permits to Work (PTW) across site; a process that is designed to monitor the efficacy of the PTW system, i.e. it does not look in detail at the specific jobs detailed on the PTWs;
- (iv) There are zero PTWs from 2008 that relate to the rodder jamming or \$\(\bar{2}(5)(a)\)

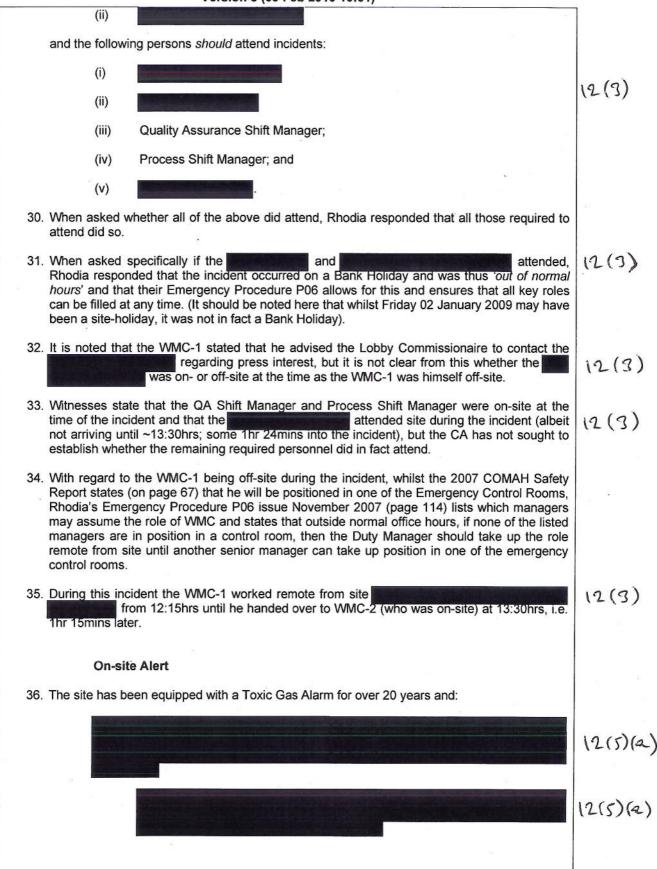
(v) In contrast, the rodder did stick on a number of occasions during 2008 but this did not cause a safety issue;

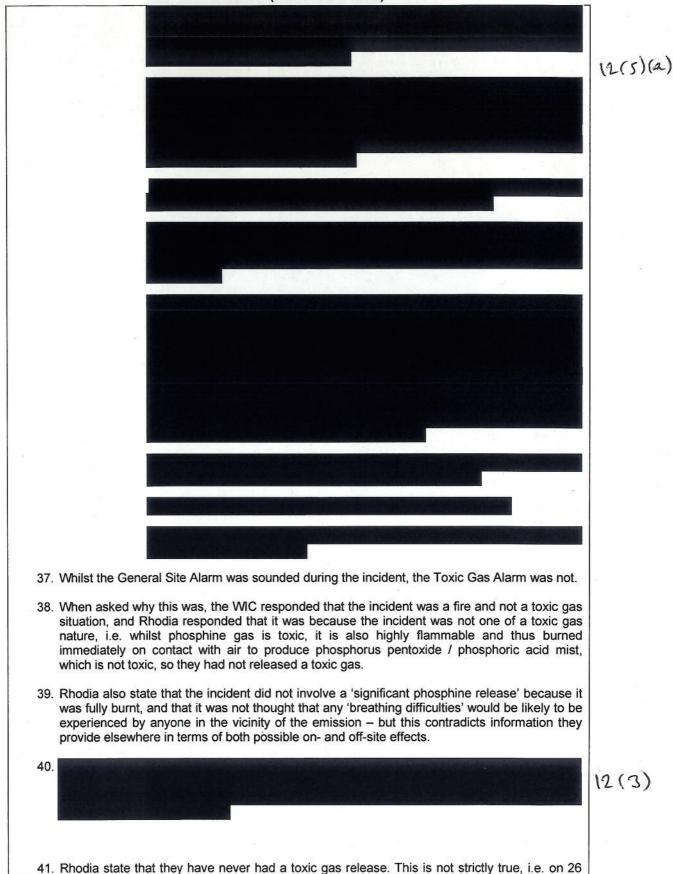
(vi) did stick on a number of occasions but no failure occurred, whereas there

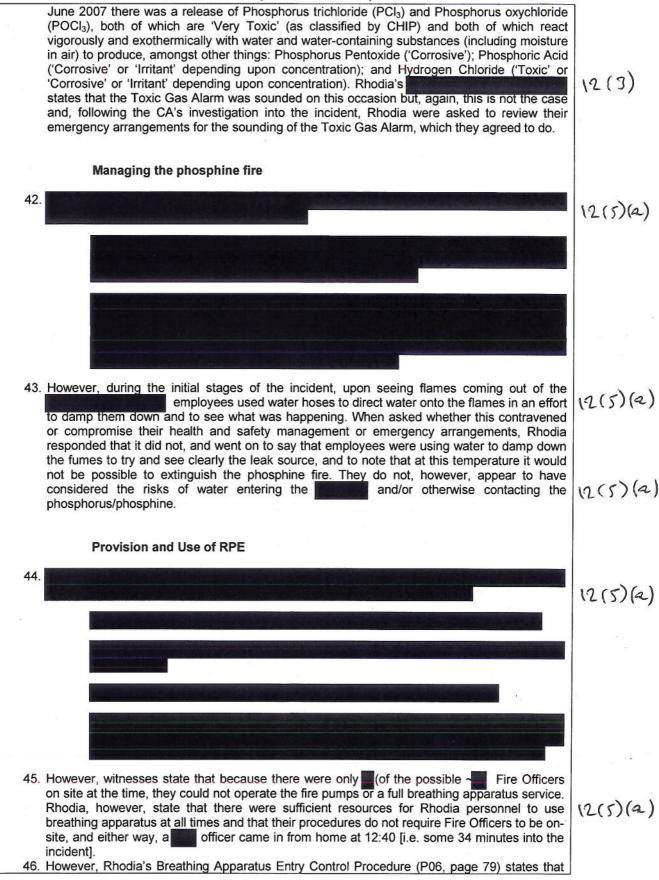
					31011 3 (03 1 613 2010 10:01)	laune	12(5)(2)
			were n	o incider	nts of sticking on but a failure did occu	r.	1.7(2)()
16. In response to the CA's request, Rhodia provided a total of 6,978 Work Orders raised for both planned and unplanned maintenance on the for 05 Jan 2005 to 02 Jan 2009 and, whilst they reported that they had split out those relating to the maintenance of the rodder and had identified one WO that had been incorrectly assigned to the when it actually related to the rodder, as the CA wished to establish the maintenance history for both and rodders, rodder assemblies, and they are analysed all 6,978. (Rhodia reported that they were unable to provide those for 02 Jan 2004 to 04 Jan 2005 as they were on an older version of their SAP database).							
17.	mainter	nance of 02 Jan	n the 2009, a	and thes	of 125 PTWs raised for both plan rodders, rodder assemblies, e were also all analysed. (Rhodia report have a policy of retaining PTW books fo	and for Mar ed that PTWs prior to	12(5)(a)
18.	Analysi	s of the	WOs an	d PTWs	showed that:		
		(i)	Not all	WOs ap	peared to have a corresponding PTW and	d vice versa; and	ž.
		(ii)			PTWs were clear in terms of the plant persons responsible for the work).	and/or work involved	
19.	Howev	er, beari	ng in mi	nd the al	bove it would appear that:		25
		(i)			007, the was removed was removed and replaced and a new rodder was provid	(for routine statutory ed;	12(5)(2)
		(ii)		Sep 20 sual; app	08, the was replaced again parently due to concerns regarding corros	in (i.e. 12mths earlier ion found on	12(5)(2)
		(iii)	this tim	ne and v	at the rodder underwent its annual insper vas found to be satisfactory and was re te, the rodder that failed on 02 Jan 2009 v	placed without repair.	
		(iv)	the 12 cases Depart Operat	month pof a j ment to ives wo report it	PTWs relating to the freeing of a jammed/ period prior to the incident. That said, it jammed/stuck rodder were referred be addressed under a WO and P uld sometimes attempt to free the rod to the Maintenance Department only i	is known that not all to the Maintenance TW regime, i.e. the dder themselves and	12(5)(2)
		(v)		are, hov I2 month	wever, the following PTWs relating to the period:	ne rodder* for the	12(5)(2)
		Date:		Ref:	Task:	Completed** after:	
		02 Feb	2008	14970	Re-attach coupling on rodder	1 hour	g.
		31 Mar	2008	10576	Check and repair rodder	3 hours	
		Apr 20	08	Various	s Replacement of and rodder	N/A	12(5)(a)
		08 Sep	2008	15002	Remove rodder for inspection	8 hours	
		12 Sep	2008	15104	Replace rodder	N/A	383
		03 Oct	2008	18775	Check rodder and gland	2 hours	

		Ver	sion 5 (09 Feb 2016 10:01)		
(A	10 Oct 2008	15604	Free rodder	5.5 hours]
	17 Oct 2008	15623	Free rodder	3 hours	
	20 Oct 2008	15630	Check and repair rodder	1.25 hours	
	28 Oct 2008	15663	Check and repair rodder	1 hour	
	04 Nov 2008	15697	Check and repair rodder	1 hour	
	10 Nov 2008	17993	Rodder jammed in down position	?	,
2 2	13 Nov 2008	17907	Check and repair rodder (jammed)	0.25 hours	
	20 Nov 2008	?	Free up sticking rodder	0.25 hours	X.
6	23 Nov 2008	17937	Free sticking rodder	1.25 hours	
	28 Dec 2008	16805	Free up rodder (jammed at top end)	0.5 hours	
	both and	(i.e. the	ot under investigation. This investigation	gured differently to that	12(5)(2)
	stopped for a would require new PTW to be	period be either the issued. of the a	ere all completed and not 'suspended' efore it was completed and then re-start e PTW to be revalidated upon re-start. The latter would give rise to more than bove PTWs relates to a discrete task a started.	ted). Suspended work ng the work or else a one PTW for the same	
investi and	gation/freeing/rel for the period f	lease of a from the	request, Rhodia provided just 3 F a jammed/stuck rodder on both date of the incident of 02 Jan 2009 to the e. a period of 2 years 9 months) (see TF	n e date of the planned	12(5)(a)
	Date:	Ref:	Task:	Plant	
	07 Dec 2010	034563	Repair rodding unit (Jammed)	?	
	28 Jan 2011	027279	Free rodder – stuck		12(5)(2)
	08 Feb 2011	027349	Free rodder		(2(3)(~)
	lld be noted, of criod than it had b		hat the plant may have been in shut-done to the incident.	own more often during	
Information, Instruction and Training					
22. At the either:	time of the incid	dent the	re were no documented procedures an	d/or specifications for	-
a)	Constructing th	e screw	joint of the two piece rodder;		
b)	Constructing, ir	nspecting	or testing the weld on the two-piece rod	der;	
c)	Adjusting the ro	odder to	ensure the necessary level of straightnes	ss;	

			VC151011 0 (00 1 CD 2010 10.01)	
		d)	Setting up the rodder assembly;	-
		e)	Setting up the rodder;	
		f)	Aligning the rodder with the inlet	12(5)(0
		g)	Freeing a stuck/jammed rodder.	
	23.	the roo	whilst there were some (brief) instructions (dated May 2007) regarding the operation of dder, the two Operatives (i.e. Team Leader and Deputy Team Leader) were both re of them.	*,
	24.	At the	time of the incident:	
		(i)	The had been trained how to machine the rodder by the	(2(3)
		(ii)	The Welders, whilst Coded, had been trained how to weld the rodder by other Welders and/or the	12(3)
		(iii)	The worked from general engineering principles; and	12(3)
		(iv)	The Operatives had been trained how to use the rodder and free a stuck/jammed rodder by other Operatives.	=3
	On	-site an	d Off-site Emergency Plans (On-SEP and Off-SEP)	
	25.	the inc	a's 'HSE Emergency Procedure P06' dated November 2007 was current at the time of cident and not the version dated December 2008 (which was marked 'Draft' and was ed to the CA in March 2009).	
	26.	conten externa drills	Rhodia employees having key roles in the On- and Off-SEPs were all aware of the ts of Rhodia's 'Emergency Procedure P06' and had received both in-house and al training. They are also involved in periodic desk-top exercises and weekly emergency which, Rhodia report, include the use of breathing apparatus, radio control and gement, etc.	
			Availability of key personnel	
	27.	respon excess and ma	asked how many employees were on site at the time that the incident started, Rhodia ded that there were a number of employees on site and that the number present was in sof that required for the Company's safety procedures to be appropriately implemented anaged. The Lobby Commissionaire, however, states that there were around people on the day.	12(5)(4
	28.	employ employ around	ting to pages 97-99 of the 2007 COMAH Safety Report (i.e. diagrams showing yee distribution across the site) it would appear that on weekdays there are around grees on site; on week nightshift there are around and at the weekend there are 150, so 15 employees would appear to be a relatively small number. That said, the day incident was a site holiday and, it is understood, only the was in ion.	12(5)(
0	29.	On-SE	than stating the minimum number of employees required to be present in order that the P and Off-SEPs may be implemented, Rhodia's Emergency Procedure P06 states that lowing persons <i>must</i> attend incidents:	
			(i) and	12(3)







their Senior Fire Officer will give orders that breathing apparatus will be used if any doubt exists as to the safety of working conditions and describes how this entry control will be maintained and what will be done in the event of a breathing apparatus wearer failing to withdraw at the proper time. It also states that breathing apparatus teams are to consist of no fewer than two wearers and that they are not to enter or be left in a risk area alone, and that where possible two breathing apparatus wearers should be kept available at the Entry Control Point for emergency purposes.

- 47. In the early stages of the incident employees entered the plant and attempted to fight the fire with water hose reels and to close the isolation valve. When asked whether the fact that they were not wearing breathing apparatus at the time contravened or compromised their health and safety management or emergency arrangements Rhodia responded that it did not, and went on to state that employees took a conscious decision not to use breathing apparatus in the first instance because they could see both the flame and the plume and therefore could avoid the fire, and that at all times their Fire Officers wore protective fire fighting clothing and breathing apparatus when they were at risk of coming into contact with the fumes.
- 48. With regard to Rhodia's claim that their procedures do not require Fire Officers to be on site, that would appear to be incorrect, i.e. the presence of their own fire brigade and fire appliance (manned and operated by volunteers) is described as part of their overall emergency response arrangements.
- 49. The 2007 COMAH Safety Report and Rhodia's Emergency Procedure P06 issue November 2007 both describe the duties of the Site Chief Fire Officer and the Site Fire Brigade Members in the event of an incident; indeed P06 does this in the section entitled 'Key Personnel Duties'.
- 50. They state that the role of Chief Fire Officer is assumed by the most senior member of the Site Fire Brigade and that he will take advice from the WIC. They state that it is his responsibility to limit the spread of any fire and, if appropriate, set up an Entry Control Point to a fume-laden building (this latter being described as being 'Of particular importance') and provide an Entry Control Officer and ensure adequate supplies of breathing apparatus are available. His duties are further described as:
 - Ensure maximum turn-out of the Works Fire Brigade members;
 - (ii) Ensure attendance of the Works Fire Brigade appliance at the scene;
 - (iii) Deploy the Works Fire Brigade men and equipment to best effect to limit the spread of fire until such time as the West Midlands Fire Service attend;
 - (iv) Consider the need to open the meter bypasses on the towns water supply for additional water;
 - Take up an advisory role for the West Midlands Fire Service and provide any assistance required;
 - (vi) Set up emergency communication point at a location agreed with the WIC using signs from the fire appliance/chemsafe tender; and
 - (vii) Give authority to sound the 'all-clear' following incident.
- The Site Fire Brigade Members duties include making the fire appliance ready and attending the scene.
- 52. If it was the case that none of the above actions were required, or would only be available when suitably qualified employees were on site in sufficient numbers, then Rhodia's emergency procedures would presumably state this and would describe alternative controls, but they do not appear to do so.

Assessing Likely Off-site Effects

53. With regard to assessing the likely off-site effects:

Rhodia's Emergency Procedure P06, November 2007, page 23, paragraph 8, requires the Works Incident Controller (the WIC) to:

'Consider the offsite effects likely to be created and take action to inform outside emergency services, and send out patrols to assess the extent of offsite effects.'

- 54. The WMC-1 (who was off-site throughout and was at no time informed that fumes were going, or indeed had gone, off-site) assumed that patrols had been sent out.
- 55. The TIC's impression was that the incident would have an off-site effect.
- 56. The WIC, however, did not feel that there were going to be any off-site problems as it wasn't toxic, i.e. it was a [Indeed Rhodia stated that it [i.e. phosphoric acid] is

12(3)

- 57. The TIC states that he and the WIC had an exchange of views and discussed how they should handle the situation, but no patrols were sent out.
- 58. When asked why patrols were not sent out during the incident and whether this contravened or compromised their health and safety management or emergency arrangements, Rhodia responded that their arrangements were not contravened or compromised and that they did a worst case analysis of the concentration of phosphorus pentoxide and phosphoric acid that would or could be at the perimeter fence and that it was well below the level for occupational health.
- 59. When it was pointed out to Rhodia that this modelling of concentrations etc. appeared to have been done via computer, Rhodia's (who was authorised to speak on behalf of Rhodia) agreed with the CA that it would have been difficult to do this assessment actually during the incident itself.

12(3)

- 60. When asked whether the above assessment was carried out during or after the incident, Rhodia state that the decision not to send out boundary patrols was based on a 'visual assessment' made shortly after 12:12 hrs (i.e. when they apparently first became aware that fumes were going or had gone off-site) that the fumes were not likely to create a problem off-site as the mist was high in the air, indicating even further dilution. They state that this was a significant factor in determining that there were not going to be any off-site effects and that a distinction must be drawn between the cloud going off-site and the potential for impact, i.e. the phosphoric acid mist was high up in the air and was not a danger to public health.
- 61. It should be noted, however, that witnesses describe the cloud when it was in the yard as being either 'on the ground' or 'hugging the ground' and one states that he and others were standing in it.
- 62. Rhodia state that these types of scenario were assessed prior to the incident in the COMAH Report (see p476). However, when asked how they could be sure of the concentrations at the time, Rhodia state that they do not model these types of scenario as they are known not to have a significant offsite impact. These two statements appear to be contradictory.
- 63. Rhodia state that at ~14.00hrs it was decided, by the in collaboration with WMFS, that the off-site alarm would need to be sounded. Rhodia state that this was in order to ensure consistency with the actions being taken by the Police who were informing people with loud hailers to stay indoors and setting up road closures, etc. Rhodia's however, states that it was because they were beginning to get concerned at that point of the concentrations.

12(3)

Off-site Alert

- 64. It is the duty of the Local Authority (LA) to draw up the Off-SEP in liaison with the Operator. In the case of Rhodia's site, it is understood that the LA delegated this work to the WMFS. The duty to implement the Off-SEP however, lies with Operator and the LA (or in this case WMFS), and they are deemed to have discharged this duty when there are systems in place to ensure that there are no unreasonable delays between the discovery of a major accident, or an incident that may lead to a major accident, and activation of the Off-SEP.
- 65. Publication HSG 191 'Emergency Planning for Major Accidents' (first published in 1999 and available from HSE Books) provides guidance on good practice for emergency planning and states that the plans must specify the name(s) or position(s) of the people authorised to initiate them and that the On-SEP should also specify who is responsible for sounding any alarms in the event of a major accident.
- 66. Rhodia's site has been equipped with an Off-site Alarm (i.e. siren) for over 20 years and their Emergency Procedure P06, November 2007, page 100 states:

'An off-site Alarm is also available should the situation warrant it.'

- 67. Rhodia state that the purpose of sounding this alarm is to warn the public of a toxic gas release. It has never been sounded other than for test purposes and, following the MA of 26 June 2007. Rhodia were asked to review/revise their arrangements for the sounding of both on- (including toxic) and off-site emergency alarms, which they agreed to do.
- 68. With regard to alerting members of the public liable to be affected in the event of a COMAH Major Accident MA (i.e. those within the Public Information Zone - 'PIZ') there is no specific requirement for a COMAH Operator to provide an off-site siren/alarm, i.e. the public may be alerted by means of e.g. telephone, loud hailer or some other system (or, as is often the case, a combination of two or more of these), and the means of alerting those within the PIZ is for local agreement and recording in the Off-SEP.
- 69. It should also be remembered that a siren/alarm may be of limited value in terms of alerting those within the PIZ who are either visiting the area or are travelling through at the time of a MA, and such persons (who would be unlikely to be privy to the information provided by the Operator in accordance with COMAH Regulation 14 and thus may be unaware of the significance of the siren or the action to take upon hearing it) would be reliant upon other means of raising the alert.
- 70. It is, however, vital that whatever system of alert is agreed upon, it is used in accordance with the agreed protocol as defined in the site's Off-SEP.
- 71. In terms of Rhodia's off-site alarm, the WIC states that it would be sounded for anything

He saw no need for it to be sounded on this occasion and states that it is

left up to the WMFS to decide whether the Off-site Plan should be activated.

72. The WMC-1, however, states that the decision regarding the sounding of emergency alarms is down to the WMC, and Rhodia's Emergency Procedure P06, November 2007, page 114 does indeed require the WMC to consider instructing the Lobby man to sound the Off-site Alarm, normally after consultation with the WIC and the Senior WMFS Fire Officer and the Senior Police Officer.

12(5)(a)

d o s re 1 th	Rhodia's procedures also require the WMC to maintain a speculative review of possible developments throughout the incident. When asked why the WMC-1 (on duty from the onset of incident until approximately 13:30hrs) was at no time notified of the fact that the cloud of moke/fume from the incident was either going, or had in fact gone, off-site, Rhodia desponded that the WMC-1 was in regular communication with other persons on-site until 3:30hrs and during this time there was not considered to be a risk of off-site impact and that the important point here is not whether the cloud migrated off-side but whether there was off-ite impact.
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74. On his way to site WMC-2 observed wisps of cloud from the incident and smelt combustion produces of phosphine on nearby Titford Road. He stated, when questioned, that he could not remember whether, upon arrival at site, he mentioned this to the

12(5)(b)

- 75. When asked who in the company the WMC-2 reported his observations to, Rhodia responded that as WMC-2 he would not have to report it to anyone. This seems unlikely as one would have expected information such as the sighting of the cloud off-site as being critical to their management of the incident and of particular relevance to all those contributing to the ongoing (i.e. dynamic) assessment of the risks.
- 76. Rhodia state that they did not sound the Off-Site Alarm at the time of the incident as a result of careful consideration having been given to the potential impact of the fire on the surrounding area, and that this was discussed between them and WMFS shortly after the latter attended site, and that as part of this discussion they gave WMFS details of the wind direction and speed using information from the weather data logging system installed in the Lobby. The consensus was not to raise the Off-site Alarm. Rhodia state that they did not believe it was an off-site incident and so did not declare it as one.
- 77. The WMC-2 states that at around 13:30hrs the Site Manager/Director reported to him that he had liaised with WMFS and that they did not wish the off-site alarm to be sounded at that time. Rhodia state that it was agreed with the WMFS that an off-site impact should not be called at that time despite the police's actions (i.e. they were setting up road blocks and advising locals to stay indoors). Rhodia also state that following a further discussion between the Company and WMFS at around 13.40pm, WMFS indicated that they did not want to sound the Off-site alarm as they were concerned about alarming the public.

12(3)

- 78. When asked whether the decision to not sound the Off-site Alarm contravened or compromised their health and safety management or emergency arrangements, Rhodia responded that it did not.
- 79. As previously described, however, at around 14:00hrs the the WMC-2 that he had again liaised with WMFS and that the incident was to be declared off-site and the off-site plan was to be activated and the Off-site Alarm sounded. Rhodia state that this was in order to ensure consistency with the actions being taken by the Police who were informing people with loud hailers to stay indoors and setting up road closures, etc. Rhodia's however, states that it was because they were beginning to get concerned at that point of the concentrations.

15(3)

80. Rhodia did not, however, sound the off-site alarm because, at around 14:15hrs, the rodder was re-inserted into the state, in collaboration with WMFS they agreed that as there was going to be no further fume emission, sounding the alarm would not be necessary.

12(3)

(2(5)(a)

- 81. Rhodia state that they did liaise with the emergency services during the incident and that Bronze Control was established by WMFS on-site and they liaised closely with them on a regular basis about the actions that were being taken to tackle the fire.
- 82. Contrary to the notes taken by the EA during the incident de-brief, Rhodia state that they were not asked to attend Silver Control (which had been set up at a local police station) and that the did speak with two of the Police Officers who attended site, but that by this time the Police had already initiated the vast majority of their actions as per the Off-SEP, and that closer liaison (i.e. between Rhodia and the Police) may have led to a more consistent approach. They also state that Gold Control was also set up but they were not asked to attend.

12(3)

- 83. When asked whether there were any off-site incidents that did not require the sounding of the off-site alarm, Rhodia responded that some incidents (e.g. spillage to canal) do not require the sounding of the offsite alarm.
- 84. The Off-site Alarm has never been sounded other than for test purposes.

Contacting Vulnerable Premises

- 85. Rhodia's site is surrounded by a mix of residential / industrial / retail / hospitality / school / care / office / etc. premises. (It should, of course, be noted that the incident occurred on Friday 02 January 2009, which means that some of these premises may not have been occupied or fully occupied).
- 86. Pages 268-270 of Rhodia's Emergency Procedure P06 November 2007, lists a total of 43 'vulnerable' premises around the site (identified according to colour-coded sectors).
- 87. These 43 include: railway stations; schools; a PO sorting office; industrial units; offices; churches; a temple; a swimming centre; a community centre; libraries; a residential home; an adult training centre; a physically handicapped centre; superstores and other retail units; youth centres; a Citizens Advice Bureau, a health centre; a neighbourhood office; a family centre; etc.
- 88. The Lobby Commissionaire states that he announced on the site ratio that the affected areas on-site were brown, green and purple (see <u>Annexe 61</u>). Assuming that these colours correlate to those in Rhodia's Consultation Zone, and they appear to do so, then there were 15 vulnerable premises relevant to the incident, i.e:
 - (i) 2 superstores;
 - (ii) 1 primary school;
 - (iii) 1 family centre;
 - (iv) 1 adult training centre;
 - (v) 1 physically handicapped centre;
 - (vi) 4 churches;
 - (vii) 1 community centre;
 - (viii) 1 office;
 - (ix) 1 library;
 - (x) 1 residential home; and

(xi) 1 Christian centre.

- 89. However, there appears to have been some confusion as to the wind direction, so it may well be the case that other vulnerable premises were in fact relevant.
- 90. Rhodia's Emergency Procedure P06, November 2007, page 28 requires the WMC to ensure that nearby neighbours, and in particular local schools, are informed if they are likely to be affected, and page 114 again requires the WMC to ensure nearby neighbours are informed and refers him to the above list of vulnerable premises. (With regard to the schools, it could be argued that they would most likely be empty due to it being a school holiday, however some schools do, of course, open for other activities/clubs etc. during holidays. Either way, schools are not the only vulnerable premises).
- 91. Rhodia state that they did not contact vulnerable premises because they reached a consensus with WMFS that neighbours were not likely to be affected, but that the Police did make contact.
- 92. When asked which premises were contacted and what information was provided and at what time, they responded that the CA should obtain this information from the Police.
- 93. When asked what relevant information they provided to the Police (or any other relevant outside agency) for them to provide to vulnerable premises, and at what time, they responded that the police had their own plan of action which was implemented in their own timeframe.
- 94. When asked if they checked with the Police (or any other relevant outside agency) that they had provided relevant information to vulnerable premises, Rhodia responded that the Police were already contacting the general public in accordance with their own plan.
- 95. When asked at what time they checked, or if they didn't check, why not, Rhodia referred to their above responses and provided no further information.
- 96. Rhodia state that there were no risks to vulnerable persons off-site.
- 97. However, Plant Emergency Dossier, March 2005, page 7, paragraph 1.4.9 states:

98. When asked whether the substances contained in the cloud that went offsite were dangerous and/or hazardous to health, for example for vulnerable persons, Rhodia referred to their above responses and provided no further information.

Keeping records

- 99. The CA publication HSG191 'Emergency Planning for Major Accidents' describes the 'Site Main Controller' (e.g. Senior Manager, Manager or Director who has an overall knowledge of the site) as having overall responsibility for directing operations from the on-site Emergency Control Centre (ECC). It describes the Site Main Controller's responsibilities as including arranging for an ongoing record to be kept of the emergency and the responses undertaken to mitigate its effects, to provide evidence of the decisions made, the mitigatory action taken, and to ensure that lessons are learned from the response to the emergency;
- 100. Rhodia's Emergency Procedure P06, November 2007, page 29 paragraph 14, requires the Works Main Controller to:

'Arrange for a chronological record of the emergency to be maintained' and it provides the form at appendix 1.A6.1 to be used.

12(5)(2)

- 101. However, no such record was kept by either of the two WMCs, who stated that they were either too busy or else couldn't concentrate on doing both this and being WMC, although one stated that he did keep some notes.
- 102. When asked why the required chronological record was not kept, Rhodia responded that people were too busy dealing with the main emergency and didn't have time to write the chronological statement.
- 103. When asked whether it was important that the chronological record be kept, Rhodia responded that they're sure it is but that this was a reaction to an emergency situation and that if they were to insist that such records were always kept this could prove a dangerous distraction from the employees' main roles in dealing with the incident.

Mechanical/Metallurgical Analysis

Royal and Sun Alliance Engineering (RSA)

- 2. The report considers the forces placed on the rodder by the motor, the gear box and the slide and concludes that the stresses within the rodder are within industry norms for the material using design stresses from PD5500. It does not consider the welded section of the failed rodder or any loading of the rodder due to misalignment, either in the weld itself or between the rodder and the talso models a one-piece rodder and uses only one loading case, and does not give any reasons as to why the weld failed in the rodder.

RCA Laboratories (RCA)

- 4. It refers to the failure of the rodder, but this is an error and, as confirmed by Rhodia, the report actually relates to the failed rodder on
- 5. The section of bar examined by RCA was the section that remained inside the the incident (i.e. HSL inspected the section that was withdrawn from the the start of the incident). The two failure areas do match.
- 6. The report does not include any calculations to demonstrate the forces required to initiate crack formation and there is no reference to the RSA report. The report states 'In summary, the following hypothesis was developed as the likely cause of the rodder failure' and summarises this hypothesis as that:
 - (i) The rodder weld was not straight;
 - Operation of the rodder produced sufficient stress to initiate a crack opposite the depression in the weld after some unknown period of operation; and
 - (iii) The cracks then grew over some period until they were sufficiently large to cause the failure seen.

12(3)

12(5)(2)

12(3)

12(5)(a)

12(5)(2)

7.	The report mentions an area of the rodder that has been damaged by external forces – such as interaction with a Stilson – but says that these were caused after the failure of the weld by the withdrawal of the rodder from the There is no evidence to support this statement as the rodder was not seen immediately prior to the incident and other rodders were seen to have mechanical damage from Stilsons or similar tools.						
8.	RCA saw only a small section of the bar and so they present no evidence regarding the condition of the remainder of the bar.						
Нο	alth and Safety Laboratories (HSL)						
	•						
9.	HSL examined the following items submitted to them by the CA:	. (6)(-)					
	(i) The failure surface of the rodder and the taken into possession on 06 Jan 2009;	12(5)(2)					
	(ii) The used rodder taken into possession on 14 Jan 2009;						
	(iii) The air reducing set taken into possession on 08 Jan 2009; and	12(5)(a)					
	(iv) The weld samples taken into possession on 27 Feb 2009.						
10.	In addition (RCA metallurgist employed by Rhodia) submitted two samples described as: (i) the fracture surface on the lower half of the rodder from (ii) a section through the weld in the rodder that had been removed from after the incident on	12(5)(2)					
11.	HSL were also provided with the drawings and data etc. regarding the rodder assembly, as submitted by Rhodia to the CA on 14 Jan 2009.						
12.	 From the above, HSL produced their report Ref: ES/MM/09/34, entitled 'Investigation of a failed rodding bar and associated items from Rhodia UL Ltd, Oldbury', dated August 2009 – Annexe 33. 						
13.	3. In August 2012, HSL were provided with copies of Rhodia's RSA Report (dated 25 February 2009) and Rhodia's RCA report (dated 18 September 2009) and asked to comment on each. They produced the letter/reports dated 09 Aug 2012 and 10 Aug 2012.						
14.	HSL concluded that the rodder had failed by rotational bending fatigue with the weld section failing first and failure progressing from the root of the weld, and then the screwed central hub of the weld assembly failing some time afterwards.	12(5)(a)					
15.	The weld was competently made but the design of the weld allowed a large lack of fusion to be left between the root of the weld and the central hub.	8					
16.	The stresses induced in a straight rodder by the rodder assembly aligned condition, even with blockages caused by were not of sufficient magnitude to cause a rotational bending fatigue fracture of the weld.	12(5)(a)					
17.	This meant that there had to be another reason why the rodder weld failed by rotational bending fatigue, i.e. there had to be another force acting on the weld in addition to the normal forces from the	12(5)(2)					
18.	Calculations by HSL demonstrated that a misalignment of the rodder assembly with the rodder on the could produce sufficient cyclic strain in the rodder to cause rotational bending fatigue failure in the rodder weld and subsequently in the central hub.	(2(5)(a)					
19.	The HSL work shows that either a misalignment in the weld or a misalignment between the and the rodder assembly was required to induce the failure seen.	12(5)(2)					

	20.	The used rodder taken into possession on the 14 Jan 2009 did not contain a weld and was made using a single piece of bar. The evidence presented by this rodder is of helical scoring on the metal surface that shows that the rodder was in contact with a material of sufficient hardness to score its surface as it rotated and slid in and out of the position of the scoring is consistent with the position of the rodder as it reaches full insertion and close examination of the markings shows that circumferential scoring becomes helical from the end of the rodder.	12(5)(2)
	21.	This rodder was not seen fitted to the rodder assembly and so no measurements could be taken, but assuming that the bar was inserted into the with staying out of the the scoring would align with the inserted end of the bronze bush (i.e. Item 2 on drawing 4341). It should be noted here that the failure in the weld on the was approximately from the top end of the rodder, and the used rodder in this position shows significant helical markings.	12(5)(2)
	22.	The used rodder also shows a significant surface disruption towards the free end that is consistent with the use of Stilsons to free a rodder that had become stuck. This can be seen clearly in Figure 4 of the HSL Report – see <u>Annexe 38</u> .	
	23.	HSL further report in section 2.3 that the sample of the failed rodder exhibited a limited number of isolated examples of heavy longitudinal scoring, which had apparently been caused by mechanical contact during longitudinal movement. These marks are on a section of the rodder that would not have been inserted into the so they cannot be related to contact between the rodder and the The reason for these marks has not been established. No helical pattern was reported, as seen on the used rodder, but it must be noted that the lower section of the bar below the weld was not inspected.	12(5)(2)
	24.	The HSL Report (Annexe 33) figure 10 shows the rodder as received. A mottled section of the rodder can be seen near to the ruler. Initially HSL were not asked to report on this section but after further close visual inspection the CA asked that a sample be taken to discover what had caused this effect. The mottled area is around to from the free end of the rodder. The HSL letter of 10 Aug 2012 reports that this area has been subject to burning phosphorus.	12(5)(2)
	25.	The sample welds clearly demonstrated the difficultly of producing a straight bar using the method of manufacture demonstrated to the CA. The step height in the weld was approximately after machining. If the angular displacement reported by HSL had not been corrected during manufacture then the paddle of the bar would have been approximately out of line with the shorter end of the bar when this was held square in the motor/gearbox assembly. Even with the smaller deflection noted in paragraph 2.4.4 of the HSL report of degrees the paddle would have been approximately out of line.	12(5)(a)
	26.	The compressed air reducing set taken from the rodder assembly was set to give no, or very limited, reduction between supply pressure and delivery pressure to the rodder motor and slide. Therefore the pressure to the rodder assembly would be limited only by site compressed air supply pressure.	12(5)(2)
An	alys	is of findings and Conclusions:	
	1.	It should be noted that use of the rodder was, from 1981 to 1989, a manual operation with a handle of just diameter provided for the Operative to turn and push against. Therefore it must be concluded that the torque required to keep the and the clear of build-up is very low and, for 8 years, was achieved by manpower alone.	12(5)(2)
	2.	The CA has seen nothing to suggest that the substances in the motor and gearbox assembly needed only to match one man power.	(2(5)(a)
1			

3. With the compressed air setting to the motor seen, the motor (at was expected to produce This power was converted to torque in the gearbox to give an output of This is far in excess of what a man could produce with a diameter handle. From this it is hard to see why the rodder might jam on product (as Rhodia suggested) when a man could keep the overflow clear by hand. It may be that Operatives used the rodder as a hammer rather than as a rotating tool and in reality the mechanised rodder can give a far better cleaning stroke than could be expected from a manual rodder.

12(5)(a)

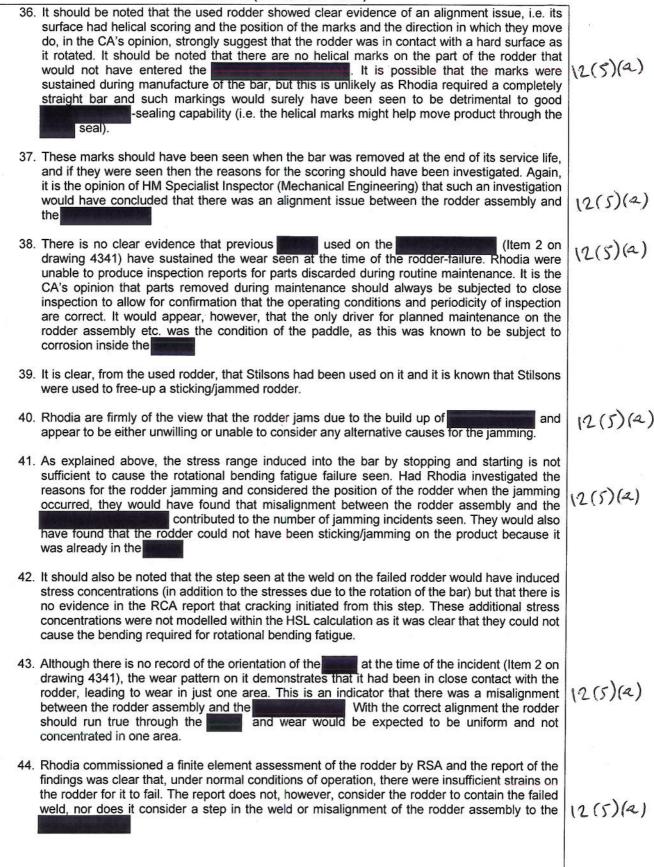
- 4. Although the CA did not see precisely how the rodder assembly was set up at the time of the incident, it is clear that the weld in the rodder failed by rotational bending fatigue and that under normal operation, with a correctly aligned straight bar, there was insufficient cyclic strain to produce a fatigue failure. The step, reported by RCA, near to the weld is not considered to have influenced the failure and no evidence is presented by RCA that cracking initiated in this area. Furthermore, no calculations are offered by RCA to demonstrate where the stresses required to initiate crack growth were generated from.
- 5. The HSL calculations clearly support the view that bending of the bar was required to produce the rotational bending fatigue seen. It was thus concluded that there had to be cyclic forces acting on the bar in addition to normal rotation of the bar in order to produce the failure seen. Without additional cyclic forces the failure seen on the rodder weld was not credible.
- Typically rotational bending fatigue failure of shafts is seen after a very high number of cycles. The actual number of cycles to failure is dependent upon the stress range applied, i.e. the larger the stress range, the fewer the cycles required to fail the weld.
- 7. In the extreme case, one application of stress can lead to failure but this is termed as an over load, whereas a few cycles to failure is termed low cycle fatigue and typically involves stresses between yield and failure stress. Typically design will be for millions of stress cycles and the S-N curves used by HSL have a limit of 10000 cycles although PD5500 Appendix C has an S-N curve that extends the typical curves down to 100 cycles.
- For a rotational bending fatigue failure of the type seen it is expected that the stresses are below yield but well above a threshold stress where crack initiation is not predicted. At some very low stress range, failure is never predicted.
- 9. Damaging cycles are cumulative so a few large stress ranges can be added to a number of smaller stress ranges to add up to the total number of cycles to failure. As fatigue cracks progress, the stress in the remaining ligament increases and therefore it is expected that crack growth per cycle increases until just one cycle completes the failure.
- 10. In the case of the rodder, larger stress ranges may be seen on start-up or on jamming, with much smaller stress ranges during normal operation. The failure surface seen on the rodder demonstrates the crack growth per cycle – these marks are called 'striations'. A rough count of the visible striations on the fracture surface seen in figure 11 of the HSL report (<u>Annexe 38</u>) gives an approximate value of 8200.
- 11. The rodder was used for 15 months and was operated approximately every 4 hours. If each operation had three cycles that caused vibration into the converter floor (as witnessed on 15 May 2009) then, over a 15 month period of operation, there would have been an estimated 15x30x6x3 = 8,100 damaging rotational bending cycles.
- 12. Without these bending cycles it can be seen that over a 15 month period, and conservatively taking 5 minutes to complete each rodding operation (i.e. the measured time for the rodding operations witnessed was far less than 5 minutes), it can be seen that a conservative estimate of the actual rotational cycles can be found as 15x30x6x5x75 = 1,012,500 cycles.

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13.	failure stress 180Mp	g at typical S-N curves for fatigue failure of welded steels, the stress range required for in one million cycles is dependent on the weld detail and, using the S-N curves, the range varies from approximately 60Mpa for the poorest weld quality to approximately a for the best quality welding; so the actual stress range required for the rodder weld to ratigue will be somewhere between these two figures.	g
14.		ing weld quality F (this aligns with the HSL findings that the weld was correctly made) e stress range to failure is expected to be approximately 80Mpa from the S-N curve.	
15.	range - is the v (and th times produce induce 60MPa	alone could not produce this stress alone could not produce this stress. A say that the maximum stress in the rodder shaft is 60MPa at start up — and this worst case. Even conservatively assuming that the rodder jams 5 times on each use here is no evidence to support such frequency) then these stresses would be seen 10 per use or $10x6x30x15 = 27,000$ times until the failure. Partial jamming would not be the same level of stress in the bar as a full jam and re-start, and thus the stresses d in the bar during partial jamming is lower than the 60MPa quoted by RSA. Using the stress swing and the lowest quality of welding leads to a life of 1.7 million cycles and les to 8 million cycles for weld quality F.	12(5)(2)
16.	weld to	with the rodder working normally, there are not enough damaging cycles to cause the fail. The weld, however, did fail, and so there had to be another force acting on the to cause it to fail within 15 months.	
17.	jammin by rota cycles,	on the plant on 15 May 2009, the CA experienced high forces transmitted by the rodder in the Working backwards from the knowledge that the weld failed ational bending fatigue, and using the forces experienced as a method for counting it can be seen from the S-N curve that for quality level F welds a stress range of above as is required to fail the weld in the 8100 damaging cycles calculated above.	(2(5)(2)
18.	the root then b assemi	vel of stress range cannot come from the normal operation of the rodder but requires lider bar to bend during each of the damaging cycles. The intensity of the stress range ecomes a function of the distance between the fixed points given by the rodder bly and the The shorter this length, the higher the stress range. Odder was correctly aligned the stresses in the rodder bar would remain constant within its given by the RSA report for removal of the	12(5)(2)
19.	aware	e opinion of HM Specialist Inspector (Mechanical Engineering) that if Rhodia had been of the rodder jamming as it approached the end of its stroke then they should have out an investigation into the cause of the jamming, and that in doing so:	
	(i)	They would have found the wear on the	12(5)(2)
	(ii)	They would have noted the vibration;	· · · · · · · · · · · · · · · · · · ·
	(iii)	They would have realised that in the jammed position the rodder paddle was inside the so was not sticking/jamming on product in the and	12(5)(a)
	(iv)	They would have concluded that the rodder and the were not correctly aligned and that they needed to be correctly aligned in all conditions of use.	(2(5)(a)
20.	temper	al expansion of metals is a physical fact. As temperatures rise metals expand and as ratures fall they contract. This expansion is linear and is well known and can be sed by a simple formula:	1
		Expansion = Original length x temperature change x thermal coefficient	
21.		sinless steel the thermal coefficient is known to be 16×10^{-6} /C so, for a 1m length and rature rise of 1 degree, the steel will increase in length by 0.016mm. For 100 degrees	

this increase becomes 1.6mm and for 200 degrees 3.2mm.

jacket) being at close to the water temperature (i.e. between 80 and 100°C). This makes the actual movement of the water temperature (i.e. between 80 and 100°C). This makes the actual movement of the water temperature (i.e. between 80 and 100°C). This makes the actual movement of the water temperature (i.e. between 80 and 100°C). This makes the actual movement of the water temperature (i.e. between 80 and 100°C). This makes the actual movement of the water temperature (i.e. between 80 and 100°C). This makes the actual movement of the water temperature (i.e. between 80 and 100°C). This makes the actual movement of the water temperature of the rodder to the water jacket and is at an upward angle) difficult to predict. 24. It should also be noted that the alignment of the rodder to the water jacket and is at an upward angle) difficult to predict. 24. It should also be noted that the alignment of the water jacket and is at an upward angle) difficult to predict. 25. It should also be noted that the alignment of the water jacket and is at an upward angle) difficult to predict. 26. On 02 Jan 2009 the mean temperature is reported as zero centigrade with the minimum at -5 and the maximum +4. Therefore it can be seen that the was much cooler than the and the steel work supporting the assembly can be expected to contract slightly from the position it would have occupied in warmer months. There were no arrangements in place to ensure any compensation for these changes. 27. The ambient temperature on 02 January 2009 at the time of the incident is reported as zero centigrade. This would have the net result of increasing any misalignment between the rodder assembly had been correctly aligned when cold, and then not realigned for the rise in temperature of the this would leave the rodder assembly too low. This would not be apparent with the rodder fully withdrawn from the		22.	In the case of the the point of interest was the bottom of the drawing 4341). The CA asked Rhodia to measure the height of this point above the support structure. Expansion above the support structure would be upwards, and below the support structure downwards. Rhodia's provided (by email dated 06/03/09 08.44) a surement of and a temperature differential between cold and full operation of This led the CA to conclude that the would rise relative to the cold and full operating temperature.	12(5)(2) -12(3) 12(5)(2) 12(5)(2)
time of the incident is not known; all that is known is that it had been aligned by eye in the cold condition. So the use of the deflection values given by the HSL report should only be read as informative to demonstrate the stress ranges in the rodder that would be induced by a misalignment between the rodder and the stress ranges required to cause rotational bending fatigue failure of the rodder within the 15 month period and this correlates with the CA's experience of the operation of the rodder assembly with the stress ranges required to cause rotational bending fatigue failure of the operation of the rodder assembly with the structure being fully open to the elements and was maintained at ambient temperature; the structure being fully open to the elements and was maintained at ambient temperature; the structure being fully open to the elements and was maintained at ambient temperature; the structure being fully open to the elements and was maintained at ambient temperature; the structure being fully open to the elements and was maintained at ambient temperature; the structure being fully open to the elements and was maintained at ambient temperature; the structure being fully open to the elements and was maintained at ambient temperature; the structure being fully open to the elements and was maintained at ambient temperature; the structure being fully open to the elements and was maintained at ambient temperature; the structure being fully open to the elements and was maintained at ambient temperature on 2 January 2009 at the time of the incident is reported as zero centigrade. This would have the net result of increasing any misalignment between the rodder assembly too low. This would not be apparent with the rodder fully withdrawn from the case described by HSL where an ambient temperature of approximately 20 C is assumed. 28. If the rodder assembly had been correctly aligned when cold, and then not realigned for the rise in temperature of approximately 20 C is assumed. 29. The HSL calculations show t		23.	the inside of the shell being close to the contents temperature (i.e. approximately) and the outside of the shell (in contact with the water in the cooling jacket) being at close to the water temperature (i.e. between 80 and 100°C). This makes the actual movement of the the contents temperature (i.e. approximately) and the outside of the shell (in contact with the water in the cooling jacket) being at close to the water temperature (i.e. between 80 and 100°C). This makes the actual movement of the	12(5)(2)
26. On 02 Jan 2009 the mean temperature is reported as zero centigrade with the minimum at -5 and the maximum +4. Therefore it can be seen that the cooler than the and the steel work supporting the assembly can be expected to contract slightly from the position it would have occupied in warmer months. There were no arrangements in place to ensure any compensation for these changes. 27. The ambient temperature on 02 January 2009 at the time of the incident is reported as zero centigrade. This would have the net result of increasing any misalignment between the rodder assembly and the hot ambient temperature of approximately 20 C is assumed. 28. If the rodder assembly had been correctly aligned when cold, and then not realigned for the rise in temperature of the about this would leave the rodder assembly to low. This would not be apparent with the rodder fully withdrawn from the exposed rodder would compensate for this misalignment would become more of an issue. In the case of full insertion the motor assembly would be trying to hold the rodder down, whereas the would be trying to lift the rodder up. As the rodder continues to rotate, these two opposing forces would act on the rodder in a cyclic manner so that at one half rotation a point on the rodder is in compression, and at the next half rotation the same point is in tension. 29. The HSL calculations show that sufficient stress range is generated in this scenario to cause the weld in the rodder to fail by rotational bending fatigue. The amplitude of 246 Mpa quoted by HSL is for the difference between the general stress in the rodder from the fully withdrawn to the fully inserted positions, and it is then shown that with full insertion and rotation, stresses swing in one point on the bar from positive 246 MPa to negative 246 MPa – a swing of around 500 MPa. This leads to the conclusion (using the S-N curve approach for a quality level F weld) that the rodder would be expected to fail in less than 10000 cycles – this aligns well with		24.	time of the incident is not known; all that is known is that it had been aligned by eye in the cold condition. So the use of the deflection values given by the HSL report should only be read as informative to demonstrate the stress ranges in the rodder that would be induced by a misalignment between the rodder and the stress ranges required to cause rotational bending fatigue failure of the rodder within the 15 month period and this correlates with the CA's experience of the operation of the	12(5)(a)
and the maximum +4. Therefore it can be seen that the cooler than the and the steel work supporting the assembly can be expected to contract slightly from the position it would have occupied in warmer months. There were no arrangements in place to ensure any compensation for these changes. 27. The ambient temperature on 02 January 2009 at the time of the incident is reported as zero centigrade. This would have the net result of increasing any misalignment between the rodder assembly and the hot ambient temperature of approximately 20 C is assumed. 28. If the rodder assembly had been correctly aligned when cold, and then not realigned for the rise in temperature of the this would leave the rodder assembly too low. This would not be apparent with the rodder fully withdrawn from the exposed rodder would compensate for this misalignment. But, as the rodder was inserted into the would be trying to hold the rodder down, whereas the would be trying to hift the rodder up. As the rodder continues to rotate, these two opposing forces would act on the rodder in a cyclic manner so that at one half rotation a point on the rodder is in compression, and at the next half rotation the same point is in tension. 29. The HSL calculations show that sufficient stress range is generated in this scenario to cause the weld in the rodder to fail by rotational bending fatigue. The amplitude of 246 Mpa quoted by HSL is for the difference between the general stress in the rodder from the fully withdrawn to the fully inserted positions, and it is then shown that with full insertion and rotation, stresses swing in one point on the bar from positive 246 MPa to negative 246 MPa – a swing of around 500 MPa. This leads to the conclusion (using the S-N curve approach for a quality level F weld) that the rodder would be expected to fail in less than 10000 cycles – this aligns well with		25.		12(5)(a)
centigrade. This would have the net result of increasing any misalignment between the rodder assembly and the hot ambient temperature of approximately 20 C is assumed. 28. If the rodder assembly had been correctly aligned when cold, and then not realigned for the rise in temperature of the this would leave the rodder assembly too low. This would not be apparent with the rodder fully withdrawn from the exposed rodder would compensate for this misalignment. But, as the rodder was inserted into the would be trying to hold the rodder down, whereas the would be trying to lift the rodder up. As the rodder continues to rotate, these two opposing forces would act on the rodder in a cyclic manner so that at one half rotation a point on the rodder is in compression, and at the next half rotation the same point is in tension. 29. The HSL calculations show that sufficient stress range is generated in this scenario to cause the weld in the rodder to fail by rotational bending fatigue. The amplitude of 246 Mpa quoted by HSL is for the difference between the general stress in the rodder from the fully withdrawn to the fully inserted positions, and it is then shown that with full insertion and rotation, stresses swing in one point on the bar from positive 246 MPa to negative 246 MPa — a swing of around 500 MPa. This leads to the conclusion (using the S-N curve approach for a quality level F weld) that the rodder would be expected to fail in less than 10000 cycles — this aligns well with		26.	and the maximum +4. Therefore it can be seen that the cooler than the and the steel work supporting the assembly can be expected to contract slightly from the position it would have occupied in warmer months. There were no	12(5)(2)
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	18		the weld in the rodder to fail by rotational bending fatigue. The amplitude of 246 Mpa quoted by HSL is for the difference between the general stress in the rodder from the fully withdrawn to the fully inserted positions, and it is then shown that with full insertion and rotation, stresses swing in one point on the bar from positive 246 MPa to negative 246 MPa – a swing of around 500 MPa. This leads to the conclusion (using the S-N curve approach for a quality level F weld) that the rodder would be expected to fail in less than 10000 cycles – this aligns well with	

3	30.		hat the misalignment could come from two areas, or a mixture of both. They point to salignment and also to misalignment in the weld itself.	
3	31.	With regard	d to misalignment in the weld, looking closely at the evidence the following has to red:	
		(i)	The rodder seen in use on 15 May 2009 did not have a weld and was considered to be straight;	
		(ii)	The short end of the failed welded rodder was held in the by a keyway and as such can be expected to have been square and rotate with no deviation. If a weld misalignment is then put in the remaining of the rodder, as it rotates it makes a conical shape with the apex at the weld and the base at the paddle. The deflection along the cone will increase from zero at the weld to a maximum at the paddle, and from the weld tests this was found to be about Such a cone shape movement of the bar would be expected to wear the all the way around and not just in the one position that was found following the failure; and	12(5)(2)
		(iii)	During manufacture, the rodder is aligned between the head stocks on a lathe so that it is generally straight between the two points on the lathe but can have some distortion, quoted by Rhodia's as a target of between those two straight points. This straightness is generated by plastic deformation of the bar using a soft mallet.	(2(3) (2(5)(a
\$	32.		an be misalignment at the weld but this is only a local effect and it can be seen that cracking has not started at this discontinuity – or directly opposite to it.	
3	33.	this would tested at o on ran	explain the vibrations experienced by both rodder assemblies that the CA saw perating temperature and the fact that at ambient temperature the rodder assembly smoothly. Whereas if weld misalignment was a significant factor then the assembly expected to struggle with the bar fully withdrawn but then to free up as the bar was	12(5)(2)
	34.	fire started the HSL re position. It retracted to reported by operators	tested at full temperature on the 15 May 2009, a lon the surface of the bar after the third rodding sequence. Clearly the evidence in eport demonstrates that this had happened to the failed rodder in nearly the same is the CA's understanding that the section of the rodder examined by HSL was fully from the start of the incident and so the heat damage y HSL must have been on the rodder section prior to the incident. This means that must have seen fire with the rodder fully inserted on at least one occasion before it but the CA has seen no evidence that this was investigated by Rhodia.	(2(5)(2)
;	35.	further into	than the measurements the CA took on the 27 Feb 2009 (i.e. The evidence from the failed bar may indicate that the insertion was to around and this would move the weld at full a point inside the diameter part of Item 1 on drawing 4341 revision C. The e of this is that the rodder weld moves from an area of soft packing to the hard teel part of Item 1; the weld would have had some freedom of movement within the ground but this would be resisted within the stainless steel part. Unfortunately Item 1 was a the fire and so was not taken as evidence, although the CA did note wear in the meter part of Item 1 when it was looked at on site.	(2(5)(2)



45.	45. One issue with this investigation was that it initially appeared that this rodder was no different to other rodders that had been made and used in the same way since 1989, with no reported failures. This led to a concern as to why this bar should fail when all others have survived for their two year operating period.				
46.		however, a number of credible explanations as to why an ageing process might on one rodder but not on others that appear to be identical, e.g.	. 33		
	(i)	The other rodders' raw bar material was stronger;			
	(ii)	The other rodders' welds were deeper;			
	(iii)	The other rodders' welds were on the point of failure when the rodders were replaced;	.00		
	(iv)	The other rodders saw fewer cycles; or			
	(v)	The other rodders were better aligned with the etc.	12(5)(2)		
47.	only were rodder, an rodder and a recently mind that F	rplanation might be that not all other rodders since 1989 were in fact welded, i.e. not there no records for the management of change from a one-piece to a two-piece d not only did the design drawings not show the weld, but, other than the failed that in use on the only other rodder that Rhodia were able to produce was not discarded welded two-piece rodder, but a used one-piece rodder. So, bearing in Rhodia only make the rodders as and when they need them, and regardless of their policy of discarding used parts, it would appear that they kept this particular rodder is.	12(5)(2)		
48.	fatigue faile even with that fatigue faile stress rang 40000 for a	without a weld are far stronger and would require far higher cyclic loads to cause a ure. Noting that use is limited to 2 years due to paddle corrosion then it is clear that the foreseeable misalignment between the rodder assembly and the tit is unlikely that an unwelded bar would contain a large enough defect to lead to a ure, i.e. using the S-N curve for the highest quality welds it can be seen that for a ge of 400MPa the number of cycles to failure is in the region of 100000 compared to a class F weld. No fatigue-type indications were found on the used bar examined by the Stilson marks and the helical grooving.	12(5)(2)		
49.	and that in would be sourced to Furthermo	with a weld. Lengths of bar of up to in length are readily available and far straighter than the rodder produced with a welded joint. Clearly Rhodia had ong enough bar in the past and their drawings expected a single length of bar. The following the incident they had no problem sourcing bar of sufficient length and as to not require a weld.	12(5)(2)		
50.	move incre fact quite	an offer no explanation as to why there was a move to a welded rodder. Such a eased both production time and effort for no increase in the integrity of the bar – in the opposite; the move significantly decreased the strength of the bar and also sed its straightness.			
51.		ge in design of the rodder did not in itself lead to the failure of the rodder in on 02 but without this change the bar is unlikely to have failed in a 2 year operating	(2(5)(2)		
52.	concern fo high levels there is a	nat there was sufficient cyclic bending loading to break the rodder led to another references in the stresses in the second seco	12(5)(2		

		101010110 (00 1 00 2010 10101)	
	53.	The CA has not asked Rhodia for any detailed fatigue calculations for the ask them to complete surface non-destructive testing (NDT) of the Rhodia did this with dye penetrant and reported that no crack-like defects were found. The CA notes that dye penetrant inspection would not find crack initiation so lack of indication does not mean that there is no fatigue damage. Furthermore, the inspection was limited to the outer surface of the so any cracking on the inner surface would not be detected. Rhodia have, however, since improved their Written Scheme of Examination (WSE) for the to include close inspection for fatigue cracking.	12(5)(2)
В2	- Pr	eventative measures taken by the duty holder(s) <u>BEFORE</u> the incident	
	1.	There was an On-SEP and an Off-SEP for the site, both of which were subject to periodic test and review. Rhodia employees involved in the implementation of these emergency plans were provided with information and instruction by both colleagues and external training-providers in the form of both verbal and documented procedures. However, certain relevant aspects of the emergency procedures were not followed during the incident.	e s
	2.	Rhodia reported that they had arrangements in place for the management of change. However, there were no records regarding the change from manual to automated rodder, or from one-piece to welded two-piece rodder. These changes apparently took place prior to Rhodia's ownership of the site, but planned periodic design-review of the plant and process by Rhodia in the intervening years seemingly failed to recognise and/or act upon the significance of these changes.	2.
	3.	Rhodia reported that they had arrangements in place for the planned, periodic-design-review of plant & process, yet the HAZOP reported as being current at the time of the incident was dated 1980 and appeared to be unchanged (i.e. not revised) and did not consider either failure of the rodder or blockage of the isolation valve by the rodder.	-
	4.	There were design drawings of relevant parts of the plant which included those dated from the time that the plant was first designed, installed and commissioned, plus subsequent revisions. The drawings did not, however, show the welded joint on the rodder.	
	5.	The plant was subjected to planned periodic maintenance, i.e. the rodder assembly was inspected daily by Plant Operatives, six-monthly by the Maintenance Team, and annually by the Plant Engineering Team, and the rodder (in recent years) was replaced every 2 years. However, records were not kept of the findings of these inspections and, either way, they appeared to be mainly for the purpose of assessing the level of corrosion of the rodder and did not include e.g. examination of surface scoring on the rodder and a check of the clearance of the bush in the graduation of which would have concluded that there was an alignment issue between the rodder assembly and the	12(5)(2)
	6.	There were thrice-weekly Plant Meetings held in the Control Room and attended by management, engineers, etc. when issues of importance relating to both production and maintenance on the plant were discussed. However, incidents of the rodder jamming/sticking were either not considered or else their significance (as an indicator of a potential alignment issue between the rodder assembly and the was either not considered or was not acted upon.	(2(5)(2)
	7.	PTWs were monitored. Again, however, incidents of the rodder jamming/sticking were either not considered or else their significance (as an indicator of a potential alignment issue between the rodder and the was either not considered or was not acted upon.	12(5)(2)
	8.	Rhodia reported that they had arrangements in place for developing suitable methods for the recovery of plant following an incident, but the method statement they produced was inadequate.	

9.	Relevant persons either followed engineering principles or else were provided with verbal
	instruction and training by their colleagues regarding the manufacture, installation, inspection
	and maintenance of the rodder. However, apart from brief instructions regarding the operation
	of the rodder (of which the Operatives interviewed were unaware) there were no documented
	procedures and/or specifications for the manufacture, installation, alignment and maintenance
	of the rodder.

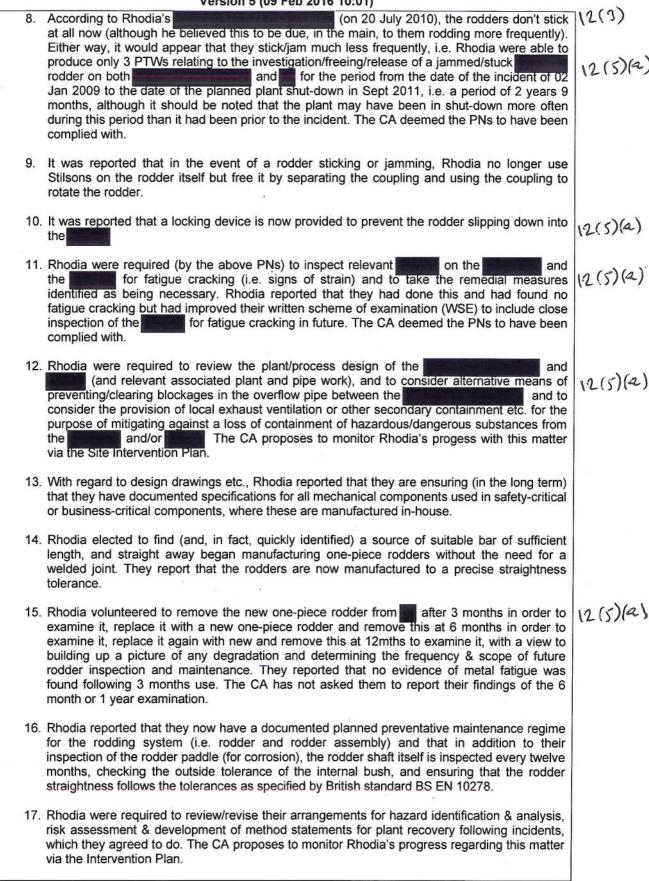
B3 - Health and safety management BEFORE the incident

- 1. On-SEP and Off-SEP.
- Arrangements for MoC.
- 1980 HAZOP.
- COMAH Safety Report 2007.
- However, certain aspects of the above were inadequate, and/or certain information contained in them was contradictory, and/or certain of the procedures described in them were not followed (see above for details).

B4 - Preventative measures taken by the duty holder(s) AFTER the incident

- Rhodia reported that they have taken steps to improve liaison with the emergency services during an incident, including agreeing standard definitions of the different levels of emergency.
- Rhodia reported that they have reviewed their emergency procedures to clarify when to sound the Off-site Alarm.
- 3. With regard to management of change, Rhodia reported that they are taking steps to ensure that relevant documentation regarding high-hazard plant is retained in perpetuity.
- 4. Rhodia reviewed/revised their HAZOP to consider the issue of 'rodder distortion', but appear to conclude that rodder failure is a production issue rather than one of H&S. It is proposed that they be asked to review/revise their HAZOP again to consider the H&S issues arising out of or in connection with rodder failure, including the potential for a failed rodder to block the isolation valve.
- 5. Rhodia reported that they are reviewing the shutdown procedures for the a view to enabling it to be shut down faster in an emergency situation.
- Rhodia elected to increase the frequency of rodding.
- 7. Rhodia were required (by two PNs, i.e. one for expansion of the expansion of the and and to realign the rodders accordingly. Rhodia reported that they initially adjusted the rodder to compensate for thermal expansion (i.e. it was reported that expansion during heating-up) but they subsequently reported that, in their view, thermal expansion was not an issue and that re-alignment to take account of it was not necessary (i.e. their measurements indicated that thermal expansion would result in a deflection of and much of this would be compensated for by the and any remaining flex would not have a significant effect upon the loads on the rodder, and that the rodder would actually flex by more than under its own weight). The CA required them to carry out further work to establish the optimum position of the rodders, which they agreed to do.

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		Version 5 (09 Feb 2016 10:01)
	18.	Rhodia reported that they now have documented procedures for the manufacture, installation, inspection and maintenance of the rodder (and have improved the existing one for the use of the rodder) and have put arrangements in place to ensure their correct implementation.
B5 -	- He	ealth and safety management changes <u>AFTER</u> the incident
	1.	See above.
LIS	то	F ANNEXES:
	1.	F2508
	2.	Map of local area
	3.	Map of site
	4.	Map of plant
	5.	Block diagram of process
	6.	
		10(5)(2)
	7.	Concinate of rodger,
	8.	Drawing 18196/2 (dated 20/05/81): General arrangement and details of
	9.	Drawing CP4353A (dated 02/05/84)
	10.	Drawing 4341 (dated 13/04/89)
	11.	Drawing 4366 (dated 19/05/89)
	12.	Drawing 4341 Revision C (dated 03/07/89): Arrangement and details of rodding facility between (2 (5) (a)
10	13.	Instructions for Rodder Operation (dated May 2007)
	14.	CCTV footage
	15.	News-site reported photo of cloud
	16.	Map of area confined by Police
	17.	Rhodia estimate of quantities released
	18.	CA estimate of quantities released
	19.	CA Report: HM Specialist Inspector, Predictive

or 'no prosecution' recommendation is approved

RESTRICTED (when complete) until prosecution concluded Version 5 (09 Feb 2016 10:01) 12(5)(2) 20. Schematic of post-incident rodder, 21. Rhodia Draft Method Statement 12(3) (2(5)(2) 22. CA Recording: 14 Jan 2009 23. Extract from 1980 HAZOP 24. CA Email re - Witnesses 04 Feb 2009 25. CA Letter re - Witnesses 04 Feb 2009 26. CA Email (2) re - Witnesses 04 Feb 2009 27. Rhodia Letter re - Witnesses 04 Feb 2009 28. Police estimate of numbers confined 29. Rhodia Newsletter Jan 2009 12(2) 30. RSA Report SS/0917617 by 25 Feb 2009 31. Diagram of relative position of rodder components with rodder fully inserted into 12(5)(2) 32. Diagram of position of rodder paddle with reference to during the rodder stroke 12(5)(a)33. Pre- & Post-incident HAZOPs (2(5)(2) Prohibition Notice 12(5)(2) Prohibition Notice Schedule 12(5)(2) Prohibition Notice 12(5)(2) Prohibition Notice Schedule 38. HSL Report ES/MM/09/34 Investigation of a failed rodding bar and associated items from Rhodia UK Ltd, Oldbury - Aug 2009 12(5)(2) 39. AVT Report 6429 22 Sep 2009 40. RCA Report 0901/002 18 Sep 2009

- 41. Rhodia Voluntary Statement
- 42. Rhodia Covering Letter
- 43. Rhodia Exhibits
- 12(5)(2) 27 Sep 2010 44. AVT Report 6429

- 45. Rhodia/DLA Letter re Foreseeability 10 Jan 2010
- 46. Rhodia/DLA Note re Foreseeability 10 Jan 2010
- 47. CA Letter re Strain 26 Jan 2011

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48. CA Composite Inspection Report re -

Strain 26 Jan 2011

(2(5)(2)

49. CA Recording: Px 03 Mar 2011 (2 (3)

50. HSL Report re - Strain 26 Mar 2011

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- 51. Post-incident instructions re rodder installation 17 Nov 2011
- 52. CA Letter re written PACE questions 16 Feb 2012
- 53. CA written PACE questions 16 Feb 2012
- 54. Rhodia Letter re written PACE questions 30 Apr 2012
- 55. CA Letter re written PACE questions 31 May 2012
- 56. Rhodia Letter re written PACE questions 14 Jun 2012
- 57. CA Letter re plant inspection 25 Jun 2012
- 58. CA Report re plant inspection 25 Jun 2012
- 59. Rhodia Letter re inspection 25 Sep 2012
- 60. CA Letter re inspection 07 Jan 2013
- 61. Map of affected areas

LIST OF REFERENCE DOCUMENTS (i.e. in addition to those listed above):

1.	All relevant correspondence and other documents held in: HSE's COIN/TRIM databases and files	
2.	HSE Report – 22 Jan 2009 – HM Specialist Inspector (Process Safety)	12(3)
3.	HSE Report – 24 Jun 2010 – HM Specialist Inspector (Process Safety)	12(9)
4.	HSE Report - 27 Nov 2012 - HM Specialist Inspector (Mechanical Engineering)	12(3)
5.	HSE Report – HM Specialist Inspector (Predictive)	
6.	CJA s9 Voluntary Statements provided by: Rhodia Unite Employee Representative / Lobby Commissionaire Rhodia Electrician / Fire Officer Rhodia	12(3
7.	PD5500 Specification for unfired fusion welded pressure vessels	
8.	(1993). Toxicity Review 30. Phosphoric acid, phosphorus pentoxide, phosphorus oxychloride, phosphorus pentachloride, phosp	12(3)
9.	HSE (2007). EH64 Workplace Exposure Limits: Diphosphorus pentoxide	
10.	HSE internal documents on establishing a DTL for phosphorus pentoxide (MH91-43a, MH91-43b).	12(3)
11.	L111 'A guide to the Control of Major Accident Hazards Regulations 1999 (as amended)'	
12.	HSG 191 'Emergency Planning for Major Accidents'	
13.	Gas Explosions in Buildings and Heating Plant by	2(3)
14.	Transcripts of Rhodia's PACE Interview of 20 Jul 2010	
15.	Rhodia UK Ltd COMAH Safety Report 2007	
16.	Rhodia UK Ltd Oldbury Site – HSE Procedure P06 – Site Emergency Procedure – Issue November 2007	

17.	edure - Issue		
18.		- Plant Emergency Dossier - Issue March 2005	(2(5)(a

- 20. Consolidated Variation of Permit SP3339BL 7 November 2007
- 21. Variation Notice KP3330XQ 29 May 2008
- 22. Extract from Application for Permit

- 26. HSL Letter dated 4th April 2011 'Review of strain measurements taken by AV Technology at Rhodia UK Ltd, Oldbury, West Midlands'
- 27. HSL Letter dated 11 May 2011 'Metallurgical examination of further components associated with the Rhodia rodding shaft failure'
- 28. HSL Letter dated 9th August 2012 'Rhodia UK Rodding bar rotating bending fatigue failure.'
- 29. HSL Letter dated 10th August 2012 'RCA Laboratories Technical report 0901/002 'Failure analysis of the rodder.'
- 30. Drawing CP4361 Revision A Details of line 'clean out' poker.
- 31. Weather report for 2nd January 2009 taken from 'wunderground.com'.
- 32. Contemporaneous Notebook Records of HM Inspectors and HM Specialist Inspectors

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