

HAZID WORKSHEET

Project Name: AEB AURORA (PCC) Project

Date:
Document Number:

31/05/2023, 07/06/2023
416041-47990/G.06/006, Rev A

No.	Guideword	Cause	Consequence	Installed Mitigation(s) / Safeguard(s)	Risk Ranking				Recommendation	Action By	Action #
					Frequency	Health and Safety	Environment	Risk			
1. External and Environmental Hazards											
1.1 Natural and Environmental Hazards											
1.1.1	Climate Extremes (High/Low temperatures,Wind,Fog etc)	High winds	Can lead to damage to the equipment's/ falling objects leading to injuries or fatal. Special attention required with respect to high structures.	The New Plant is designed for high wind loads. The New Plant has a design life of 16 years.Metereological data in listed BOD doesn't account for the climate change.							
		No Wind	In case of leakage CO2 will not be dispersed but accumulate at the site as CO2 is heavier than air. This may impose asphyxiation risks leading to loss of consciousness or even fatalities.		3	6	18	1) CO2 Personal Gas detectors should be provided to staff to carry on field. Fixed CO2 Gas Detection System shall be designed as part of the project.	AEB/EPC Contractor		1
		Low Temperatures (Ice formation)	Formation of Ice leading to slippages and falls in the plant. Also, Falling ice blocks from high structures(e.g. Stack) leading to Injuries/fatalities.		3	6	18	2) Take Ice formation risks into account during design of the installation. Operational work procedures to be also developed for this Ice Formation risk.	AEB/EPC Contractor		2
		Marine Conditions.	Salty air leading to corrosion issues at plant	Sea climate considered part of BFD							
		Fog	Low visibility at site resulting in accidents		2	3	6	3) Logistics plan to be made with attention to proper lining, safety signs, vehicle routing and lighting around the roads for low visibility conditions.	AEB		3
1.1.2	Lightning/Rain	Lightning		Other high structures / other lightning protection(e.g. earthing) available at site.							
		High Rains	Existing site sewer / containment systems for potentially contaminated rain water is not sufficient for high rains leading to overflow of the contaminated rain water on site.		3	2	6	4) Heavy rain scenario to be considered for the design of the new sewer system of the new PCC plant.	AEB/EPC Contractor		4
1.1.3	Earthquakes	No Additional Concerns									
1.1.4	Erosion	No Additional Concerns									
1.1.5	Subsidence	No Additional Concerns									
1.1.6	Floods	Storm surge	Major damage and blackout in the facility due to flooding.		2	3	3	6	5) Design shall ensure that loss of power shall not lead to hazardous consequences. Solutions such as fail safe design, use of emergency/UPS power etc. to be considered.	AEB/EPC Contractor	5
1.2 Created (Manmade) Hazards											
1.2.1	Security Hazards	No New Hazards (existing plant secured)		DCS security system (Existing DCS may be used if required)							
1.2.2	Terrorist Activities	Cyber attack	Unwanted takeover of the plant								
1.3 Effect of Facility on Surroundings / Effect of Surroundings on Facility											
1.3.1	Geographical Infrastructure (plot location)	Not applicable									
1.3.2	Proximity to Population	Industrial Area(not residential)									
1.3.3	Proximity to Transport Corridors	Industrial cargo railway and public road nearby			3	2	6	Emergency Response procedures to be developed/updated for high CO2 leakage scenario.	AEB		6
1.3.4	Adjacent Land Use	Biogas tanks and Wood gasifier factory next to new plant location	Explosion from biogas tank rupture / wood gasifier factory	QRA	2	6	12	Waternet QRA & BEN QRA to be reviewed for the impact and safety from the scenario of nearby biogas tank explosion/ wood gasifier factory fire.	AEB		7
1.3.5	Social Issues	No issues expected.									
1.3.6	Process Upset Nearby Unit(s)	See 1.3.4.									

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1.3.7	Incidents Involving Trains/Truck/Vessels (Loading)	Unloading of Bulk chemical from truck for HRC and AEC (HCL,NH3, Nitrogen, Caustic soda etc)	Pollution and health impact from spills, Collision etc.		3	2	2	6	Traffic Plan to be updated to reduce the impact from this scenario of "Unloading of Bulk chemical from truck for HRC and AEC". QRA for truck unloading operations to be shared with the neighbours as well.	AEB	8
1.3.8	Nearby Construction	Not applicable									
1.3.9	Gate Security	No additional concerns									
1.3.10	Port of Amsterdam/Security	No Additional Concerns									
1.3.11	Railway	Already discussed see 1.3.7.									
1.4 Infrastructure											
1.4.1	Normal Communication	New communication line with OCAP			5	1	1	5	Manage the interface (process control and safety systems) with OCAP	AEB Projects	9
1.4.2	Contingency Planning	No specific concerns									
1.4.3	Supply Support (Consumables/Spares etc.)	No Amine or spare parts etc available	Stoppage of operations		3	1	1	3	Sourcing Strategy to be developed for all the consumables/ spares availability.	AEB Projects	10
		No Space in existing warehouse for spare parts.	No Spare parts available when required.		3	1	1	3	Investigate if the existing warehouse is sufficiently sized to include new spares, if not proper action should be initiated.	AEB Projects	11
1.5 Environmental Damage / Impact											
1.5.1	(Continuous) Plant Discharges to Air	increased production of ammonia due to use of amine based solvent and permit values for ammonia emissions being more stringent.	permit violation		3		3	9	Process should be designed to reduce the ammonia emissions	AEB/EPC Contractor	12
					2		3	6	Consider reducing ammonia in the existing process	AEB	13
		Interaction between solvent and flue gases would lead to increased ZZS substances emissions	permit violation	part of contracting strategies with Technology provider to include no ZZS emissions.	2		2	4	Consider pilot project to test various solvents including ZZS content, ammonia in flue gas, waste water contamination and CO2 quality.	AEB/EPC Contractor	14
		Purging of driers(Co2) released to air	Hot air including water as well as CO2 Stream components released to air.		3		3	9	Consider to bring back the CO2 stream including hot air back into the stack as it is included in the permit.	AEB/EPC Contractor	15
		emergency operational upset releasing CO2 to air.	No permit violations								
1.5.2	(Continuous) Plant Discharges to waste Water treatment	waste water treatment not designed to handle ammonia	Ammonia and traces of Mercury discharged to harbour after treatment (from condensate in the DCC) leading to permit violation		3		3	9	Analyse the waste water stream and Consider to design the waste water treatment to handle ammonia after looking into various options. Optimize DeNox. Online monitoring for ammonia and mercury to be considered.	AEB/EPC Contractor	16
		Not allowed to sent the ZZS components to Municipal sewage system	Permit Violation		3		3	9	Consider to sample the waste water stream to prevent sending waste water to municipal sewage treatment which is violating permit. Consider a retention tank in design.	AEB/EPC Contractor	17
	(Continuous) Plant Discharges to Water	Too high cooling water return temperature	After PCC is in operation, discharge to surface water overall will reduce but a discharge point temperatures might increase from the discharged water.								
	(Continuous) Plant Discharges to Water	Bad mixture of biofouling system in cooling water inlet and no measurement of cooling water to PCC.	Too high chlorine and NaOCl content in cooling water to Surface water		3		2	6	Add chlorine inline measurement in the PCC cooling water inlet downstream the anti biofouling system.	AEB/EPC Contractor	18
	(Continuous) Plant Discharges to Water	contamination of Non Contaminated rain water on the road discharged to harbour	Exceedance of permit values on suspended solids or heavy metals.		3		2	6	Good House Keeping and proper maintenance on filters and water separators integrating monitoring plan should be considered.	AEB	19
1.5.3	(Continuous) Plant Discharges to Soil	No Additional concerns.									
1.5.4	Emergency / Upset Discharges	See Above.									
1.5.5	Contaminated Ground	Part of permit requirements.									

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1.5.6	Facility Impact	Schiphol airport nearby	No issues	anti collision light on the stacks							
1.5.7	Waste Steams	Activated carbon, silica gel, spent amine solvent processed at site in waste incineration.	No hazardous consequences .		5	1	1	5	Waste Streams have to be formally approved by acceptance teams.	AEB	20
1.5.8	Timing of Construction	cutting trees not in breeding season, peregrine falcon nest on the stack	Delay in construction activities		4		2	8	Construction activities to be planned keeping breeding season of birds into consideration. Consult ecological expert.	AEB/EPC Contractor	21
1.5.9	Noise	No additional concerns.									
1.5.10	Odour	Emergency operational upset releasing amine to air.	Odour Nuisance and complains	For loading/ unloading vapor return system is in place.	3	1	2	6	Consider use of quick release coupling for loading/Unloading operation.	AEB/EPC Contractor	22
1.5.11	Energy Consumption	No Additional Concerns.									
1.5.12	Use of Resources - Water	Lack of industry water during dry season.	Not Sufficient water for feed of Demin water plant. operational upset no hazardous consequences.								
1.5.13	Use of Resources - Harbour Water	No additional concerns.									
1.5.14	Products	CO2 Captured from Flue gas	Positive environmental Impact.								
1.5.15	Chemicals	No additional concerns.									
1.5.16	Flora and Fauna	See recommendations 1.5.8 and 1.5.1. No additional Concerns.									

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2. Facility Hazards											
2.1 Controls Methods/Philosophy											
2.1.1	Manning / Operations Philosophy	Manning from a separate control room and a separate group of staff.	Interface management required	Manning from existing control room							
		Potential understaffing in the project of trained operators.	Insufficient trained people to staff the plant	Onboarding of all staff. Additional Operator added to the staff.							
		Distance of PCC plant far off from existing control room	Not enough overview		2	3	6	Local Control panel station should be installed in the PCC plant	AEB/EPC Contractor		23
2.1.2	Operation Concept	Unavailability of PCC will influence availability of the AEC & HRC plant	Lower availability of AEC & HRC.	Connection to all 6 flue gas lines and downstream the ID fans. The route to stack will be always open.							
		Unavailability of more than 3 boilers will lead to unavailability of PCC plant.	Insufficient amount of CO2 will be captured.	Connection to all 6 flue gas lines and downstream the ID fans.							
2.1.3	Control Philosophy / ESD Philosophy	setpoints not properly defined	Operation outside desired operating envelope.		3	2	6	Well defined operating window and aligned with AEB internal operating control & alarm philosophy.	AEB/EPC contractor		24
		Off spec Flue gas to PCC	Poisoning of the amine solution	closed louver dampers in case of off spec flue gas.							
		failure to close the louver dampers	Poisoning of the amine solution or shutting down PCC.		3	2	6	Investigate the best solution to prevent the failure of louver dampers or mitigate in case of failure.	AEB/EPC contractor		25
		no power therefore no heating of amine	crystallization leading to plugging and blockage.	Tracing & heating installed.	3	1	3	Tracing needs to be in operation during the power failure.	AEB/EPC contractor		26
2.1.4	Maintenance Philosophy	insufficient maintenance	Loss of income and higher maintenance costs. Lack of maintenance will impact the safety.		2	2	4	Align maintenance philosophy of PCC plant with the AEB maintenance philosophy.	AEB/EPC Contractor		27
		insufficient maintenance	Loss of income and higher maintenance costs. Lack of maintenance will impact the safety.		1	3	3	Well defined maintenance and spare part work instructions to be prepared including PO orders in the ERP system.	AEB/EPC Contractor		28
		PCC plant not available while doing maintenance of louver dampers.	Availability of PCC not high enough		1	3	3	Engineer an isolation method in order to keep the availability of PCC high.	AEB/EPC Contractor		29
								A maintenance review session on the P&ID level to be organised prior to the HAZOP session.	AEB/EPC Contractor		30
2.1.5	Manning Levels	See 2.1.1 above.									
2.1.6	Concurrent Operation	See 2.1.2 above.									
2.1.7	Emergency Response				5	1	5	Integrate PCC plant in the existing emergency plan and communicate with fire brigade.	AEB/EPC Contractor		31
2.1.8	Start-up / Shutdown	off design performance of the PCC	Build-up of CO2 on the regeneration side CO2 quality is not sufficient to sent to offtaker. High pressure in stripper due to CO2 accumulation.	Purging Strategy always open vent. Vent present in stripper for off spec CO2 overpressure venting.							
		off design spec for CO2									
2.2 Fire and Explosion Hazards											
2.2.1	Stored Flammables	No additional concerns.(amine is also not considered flammable)									
2.2.2	Sources Off Ignition	Not applicable									
2.2.3	Arc Discharge (Boogontlading)	Not applicable									
2.2.4	Equipment Layout	No additional concerns									
2.2.5	Fire Protection and Response	Hotwork near GRP equipment/lines	fire (asset damage)	Hotwork procedure	2	3	6	Consider using lined steel & Discuss with insurance company	AEB/EPC contractor		32
2.2.6	Personnel Protection (operators, maintenance staff etc.)	See Section 3.									
2.2.7	Escape Routes / Evacuation	No specific concerns.									
2.2.8	Explosion (Effect calcs, ATEX Requirements etc.)	Not Applicable.									
2.3 Process Hazards											

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2.3.1	Inventory	current design of chiller with ammonia	Ammonia is toxic and explosive	PGS 13 Guidelines	1	1	1	1	Consider other coolant than ammonia for the chiller.	AEB/EPC contractor	33
		Lean Amine, Flue gas etc is corrosive and wrong material is used.	Corrosion leading to leakages and loss of containment. Poisoning of amine.	Proper Material Selection	3	3		9	Material Selection study to be executed.	AEB/EPC Contractor	34
2.3.2	Release of Inventory	LOC of Amine inventory	Amine spill causing environmental damage and safety hazards(toxic), Specially during the loading(fresh amine) /unloading (spent amine) operations.	Design storage tank according to PGS 31	3	3	2	9	Design, Handling (loading/unloading) and operation requirements related to amine storage and transport to be reviewed in the HAZOP session	AEB/EPC contractor	35
		Sulphuric acid(10 m3) inventory loss during loading/unloading	Sulphuric acid Spill (environmental issue and safety hazards)	Design storage tank according to PGS 31	3	3	2	9	Design, Handling (loading/unloading) and operation requirements related to sulphuric acid storage and transport to be reviewed in the HAZOP session	AEB/EPC contractor	36
		Leakage of CO2 inventory at 23 bar.	No icing expected, Asphyxiation and CO2 dense cloud. Also can be released in indoor for e.g. Compressor room.		3	3		9	CO2 gas detectors to be provided in the areas where CO2 leakage is expected.	AEB/EPC contractor	37
					3	3		9	Ensure proper ventilation is provided for the indoor areas.	AEB/EPC contractor	38
		Chemicals (Caustic, HCL etc) inventory	Chemicals(Caustic, HCL etc) spills	known on site and mitigation measures in place.							
2.3.3	Overpressure / Underpressure	To be discussed in HAZOP session.	Underspressure in flue gas trunk line leading to damage.		2	3	3	6	Organise technical alignment meeting with offtakers (OCAP)	AEB/EPC Contractor	39
		louwer/dampers closed when fan is in operation.			3	3		9	control philosophy for fan / louwer dampers to be reviewed during HAZOP session.	AEB/EPC contractor	40
2.3.4	High/Low Temperature	Storage temperature of amine to be kept between 25-80 degC.	Amine crystallizes(and hard to decrystallize with warming) below 25 deg leading to fouling and plugging and above 80 it decomposes leading to offspec solution.	Amine Storage tank is heated with recirculation.							
				Hold up tank installed to drain amine in case of shutdown.	3	2	2	6	Investigate if flushing of the system is needed after drainage of the amine solution.	AEB/EPC contractor	41
		Expansion of pressurise CO2 to ATM conditions leading to low temperature	Potential Brittle failure of materials, potentially leading to loss of containment		3	3	3	9	Material to be selected for CO2 looking into JT effect.	AEB/EPC Contractor	42
2.3.5	High/Low Level	To be discussed in HAZOP									
2.3.6	Composition / Phase / Contamination	Offspec CO2 . See No. 2.X.X	Cant be sent to Offtakers leading to loss of income. No hazardous consequence.								
		Offspec Flue gas. See No 2.X.X									
2.3.7	Impurities	Offspec CO2 with corrosive components.	Corrosion in the system, loss of containment eventually.	CO2 measurement system in place.							
		Contamination in Amine	offspec solvent from solvent supplier.	Contracting strategy with Process guarantees	2	2	2	4	Acceptance including testing requirements procedure for Amine should be prepared.	AEB/EPC Contractor	43
		Contamination in Amine	Offspec solvent in the system	solvent reclaimer unit in place and	2	2	2	4	Solvent management plan to be investigated	AEB/EPC Contractor	44
2.4 Utility Systems											
2.4.1	Firewater System	Existing Firewater system designed sufficiently including retention pit. No issues identified.									
2.4.2	Fuels (Fuel Gas/Diesel etc.)	Minor additional Diesel Consumption.	No Hazardous consequences.								
2.4.3	Heating Medium	Heating material is electrical tracing.	No Hazardous consequences.								
2.4.4	Power Supply	Additional Power supply for the project is under discussion.	No Hazardous consequences.								
2.4.5	Steam	Contamination of LP steam condensate from new 4 bar header with Amine.	Operational Upset. No hazardous consequences.		3	2	3	9	Add a TOC(Total Organic Contamination) measurement into the condensate line.	AEB/EPC Contractor	45
		Consumption of MP steam due to thermal reclaimer requirements.(subject to vendor design)	No Hazardous consequences.								
2.4.6	Drains	Drainage during start-up and maintenance (LOTO)	Spillage of product to ground or water		3	2	3	9	Design the drains such that (also at start up, shutdown and maintenance) medium is properly recovered.	AEB/EPC Contractor	46
2.4.7	Inert Gas	Additional minor Nitrogen gas requirements	No Hazardous consequences.								
2.4.8	Waste Storage / Treatment / Disposal options	No additional concerns.									
2.4.9	Chemical / Fuel Storage	Anti Scalant, Anti foaming chemicals to be added.	No Hazardous consequences.		2	2	2	4	Make reservation for storage and dosing of auxiliary chemicals.	AEB/EPC Contractor	47
2.4.10	Potable Water	No additional concerns.									
2.4.11	Sewage	No additional concerns.									
2.4.12	Instrument Air	CO2 Used as instrument gas.	Technical problems and potential safety risks	Decision made to not do this.							

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2.5 Maintenance Hazards											
2.5.1	Access Requirements	Not sufficient maintenance space			3	3	9	Every instrument, valve and operable equipment has to be reached without any additional temporary measures.	AEB/EPC Contractor		48
		Not sufficient maintenance space for louver dampers in flue gas lines.			3	3	2 9	Accessibility of Louver dampers in the flue gas lines should be reviewed in detail.	AEB/EPC Contractor		49
2.5.2	Override Necessity	To be discussed at later stage.									
2.5.3	Bypass Required	main bypass to the fluegas stack is always open. To be discussed in HAZOP in details.									
2.5.4	Commonality of Equipment	See 1.4.3.									
2.5.5	Heavy Lifting Requirements	Replacement of packing materials			2	2	2 4	Make sure that there is enough space to place cranes during maintenance	AEB/EPC Contractor		50
2.5.6	Transport				3	2	2 6	Define the height of pipe bridge to ensure that passage height is sufficient.	AEB/EPC Contractor		51
2.5.7	First line maintenance and Operations	Existing Maintenance station too far			3	2	2 6	Erect a first line maintenance station for the operators including LOTOTO near the PCC plant.	AEB/EPC Contractor		52
2.6 Construction Hazards / Existing Facilities											
2.6.1	Tie-Ins (Shutdown Requirements)	To be reviewed in constructability review session.									
2.6.2	Concurrent Operation										
2.6.3	(Heavy) Lifting / Digging Operations										
2.6.4	Re-Use of Material										
2.6.5	Common Equipment Capacity										
2.6.6	Interface- Shutdown/Blowdown/ESD										
2.6.7	Skid Dimensions (weight handling / congestion)										
2.6.8	Soil Contamination (existing facilities)										
2.6.9	Mobilization / Demobilization										
2.6.10	Material compatibility (e.g. metallurgy) and selection										

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3. Health Hazards											
3.1 Health Hazards											
3.1.1	Disease Hazard	See below.									
3.1.2	Asphyxiation Hazard	CO2 : Emergency operational upset releasing CO2 to air.	Asphyxiation from venting of CO2.		3	3	2	9	Safety Effect calculations for atmospheric safe location of the vents to be performed.	AEB/EPC Contractor	53
3.1.3	Toxic	Amine: Amine including additives is (repro) toxic.	Influences fertility and health damage.		3	3	2	9	Health risks of amine to be further investigated and define the impact on the design of the plant.	AEB/EPC Contractor	54
					3	3	2	9	Make the selection of solvent based on health, safety requirements in the contracting strategy.	AEB/EPC Contractor	55
					3	3	2	9	Bow-tie analysis to be performed for safe use of the selected solvent.	AEB/EPC Contractor	56
					3	3	2	9	Define the necessary PPE for safe working for amine.	AEB/EPC Contractor	57
		CO2 is toxic above a certain concentration and inhaling CO2 interferes with the metabolism.	Health issues.		2	2	2	4	Plant installed outdoor(proper ventilation) to be kept in mind when applying for building permit.	AEB/EPC Contractor	58
									CO2 Compressor will be installed in a noise enclosure in a building. Conditional access to be considered for this enclosed space.	AEB/EPC Contractor	59
3.1.4	Carcinogenic	Amine: Degradation products of Amine namely nitrosamines, nitramines are carcinogenic.	Health issues.		3	3	2	9	Formation of carcinogenic degradation products of amines need to be minimized by proper process design.	AEB/EPC Contractor	60
3.1.5	Physical	Amine : See above.									
		Amine: Skin contact	Health issues. Skin irritation		3	3		9	Requirement of Safety Shower and Eye wash or diphtheriae to be checked for areas where exposure to amine is expected.	AEB/EPC Contractor	61
3.1.6	Mental	CO2 : See Above									
3.1.7	Cryogenic (e.g. skin burns)	Not applicable.									
		See 3.15									
		CO2: expansion of CO2 from 23 bars to atm.	Potential cold burns	Vent to safe location	3	3		9	To be checked if expansion of CO2 from 23 to ATM will give a hazard situation leading to cold burns	AEB/EPC Contractor	62
3.2 Working Hazards											
3.2.1	Electric Shock	Build-up of electrostatic energy	source of ignition and cause electric shock	Earthing of the installation							
		Electrical rooms	restricted access areas.								
3.2.2	Electromagnetic Radiation	Not Applicable									
3.2.3	Radioactive Radiation	Not Applicable									
3.2.4	Noise	Compressor & Pumps making noise above 85 db.	People exposed to Too High noise		3	3		9	Ensure noise requirements are met by the vendor	AEB/EPC Contractor	63
3.2.5	Restricted Movement / Confined Spaces	See above									
3.2.6	Working in/under/on Water	cooling water intake to be extended for this project	No Hazardous consequences.	Experience and instructions.							
3.2.7	Working at Height	No New Hazards									
3.2.8	Working on Hazardous Surfaces	No New Hazards.									
3.2.9	Working with Non-Standard Equipment	Not Applicable.									
3.2.10	Transport, storage, handling	fork lift movement (maximum few times a year)	Damage to installation or fork lift trips	Proper asphalt roads.							
3.2.11	Confined spaces	leakage in Nitrogen lines in the Demin water building	Asphyxiation from nitrogen.	Use of Personal Protection O2 Detector	3	3		9	Evaluate the design of nitrogen system if it is considered indoor.	AEB/EPC Contractor	64
3.2.12	Lone working	Work alone	Incidents without knowledge of other colleagues	Portaphone system	3	3		9	Consider man down function on the portaphone system.	AEB/EPC Contractor	65

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4. Project Implementation Issues										
4.1 Contracting Strategy										
4.1.1	Prevailing Influence									
4.1.2	Legislation									
4.1.3	External Standards									
4.1.4	External Environmental Constraints									
4.1.5	Contractor management									
4.2 Hazard Recognition and Management										
4.2.1	Hazard Studies									
4.2.2	HSE Case									
4.2.3	Project Controls									
4.3 Contingency Planning										
4.3.1	Geographical Infrastructure									
4.3.2	Recovery Measures									
4.4 Competency										
4.4.1	Local Level of Expertise/Training									
4.4.2	Training Requirements									
4.4.3	Level of Technology									
	Contractors (e.g. truck drivers)									