JRC - Learning Opportunity Notification (LON) - 003

Incident Details	
Incident	Alexander L. Kielland
Date of Incident	27-Mar-80
Location/Country	Ekofisk Area, Norwegian Sector, North Sea
Type of Incident	Capsize
Offshore/Onshore	Offshore
Asset Type	Semi-Submersible
Asset Status	Operational
Immediate Cause	Damage to Structure
Similar Root Cause Incidents	LON - 001, LON - 004
Date Updated	05-Mar-21

Incident Impact	
People	123 dead
Environment	Minimal
Asset (adjusted claim at the time of loss)	USD $89.5 million
Reputation	

Incident Description

The Alexander L. Kielland was built as a semi-submersible drilling rig by Compagnie Francaise d'Entreprises Métalliques, Dunkerque, France. The rig was of a 'pentagon' design, with five legs (columns), and was one of eleven such designs, and in turn one of seven built by CFEM, albeit a modified version. The vessel was delivered to owners A.Gowart-Olsen A/S in 1976, and operated by Stavanger Drilling Company.

Whilst designed as a drilling rig, the vessel was used for the entirety of its life as an accommodation vessel (floatel), with 3 stages of modification to increase accommodation capacity from the original 80 up to 348 persons by 1978. However the drilling derrick remained in place. Design survival rules at the time required the rig remained floating in a stable position after damage resulting in flooding of two adjacent tanks in a single column.

On 27 March 1980, the rig had been at anchor and located adjacent the Edda 2/7-C Platform (operated by Phillips Petroleum) for around nine months. In the afternoon of that day due to the weather conditions, the rig was moved away from Edda platform by anchor cable adjustment, and the transfer gangway withdrawn to the rig. At around 18h30, in a storm of Force 10, with winds of 20-25 m/s, and waves 6 to 8 m high, the column 'D' broke off causing the rig to list to 30 degrees, with five of the eight deployed anchor cables broken. Twenty minutes later the final anchor cables broke and the platform capsized. It was established that bracing D6 broke first, with rapid succession failure from overloading of the other 5 bracings that connecting the column to the platform.

After extensive search and rescue for survivors, 123 of the 212 people on board lost their lives.

Investigation showed that the fracture in D-6 bracing was a fatigue failure. In this bracing there was a cut-out for a hydrophone, used for positioning control, with the column D being one of three columns with such an arrangement. The hydrophone support was fixed to the bracing by inside and outside fillet welds. Detailed post incident analysis showed the welding for the support was of poor quality and lacked penetration, this led to fractures in welded connection, which progressed to the circumference of the bracing itself, and included two-thirds of the circumference at the point of final failure. Fractures in the weld started in the construction yard as paint residue was detected on the fracture surfaces. The exact duration between initiation of cracks in the bracing and final failure was not accurately determined.

The platform heeled when the column D broke as it was not designed to have sufficient stability for such a major loss of buoyancy. The investigation determined the short duration to the point of capsize was due to rapid deck and column C & E flooding through multiple openings. With only 20 minutes to prepare for evacuation, further shortcomings in the availability and design of life-saving equipment were major contributors to the large loss of life, exacerbated by delays in the off-rig incident response.

After the incident and emergency response, the rig was towed on 19 April 1980 to Norwegian near-shore waters. The column D was towed separately to Lineosen, nr. Stavanger, and held as crucial physical evidence for the public incident investigation.

The rig, which at least initially was being consider for repair and re-use, was finally up-righted in 1983 in Gandsfjorden, with a subsequent decision made to scuttle that vessel, which happened on 19 November 1983 in Nedstrandsfjorden at a depth of more than 700 m.

It is noted that the public incident investigation, initiated by the Norwegian Government the day after the capsize through a Royal Decree in accordance with Norwegian Maritime Law, was conducted by a Commission led by District Judge Thor Næsheim. The mandate for the Commission was to investigate the causes of the incident, and further to evaluate the functioning of lifesaving equipment as well as effectiveness of evacuation and rescue operations, and to propose recommendations. The bulk of the incident analysis and findings provided in this LON are taken from summaries of the investigation findings.

Incident Analysis and Findings (including Causal Factors)

Incident analysis has been performed based on causal factors and are presented below together with the findings:

Design & Construction Standards - In specifications for the 'pentagon' design, the hydrophone attachment tubes were not considered as part of the primary structure and thus no material quality specifications applied. Poor material properties of the hydrophone tube, and poor welding resulted in cracking in the double fillet weld joining the tube to the bracing in the yard. This was not identified during construction quality checking, and continued fracturing led to two initiation sites on column D during operation. Fatigue cracking continued in the column for 60-100 mm from each initiation point. Thereafter combinations of ductile tearing and fatigue crack growth led to final facture at around one third of the remaining circumference. In this regard the fatigue fracture in the support brace D6 was the direct cause of the incident, yet the reason it occurred in the first place, goes back to lack of awareness as to the criticality of connections (in this case a welded connection) to a primary support member during the design, construction and subsequent quality assurance and control around such connections.

Design (Risk Assessment) – The 'pentagon' design did not adequately address the incidence and risk of loss of buoyancy, and allowed for only partial flooding of a column, and not loss of a column in its design. Similar inadequacies were found in the loss of two other semi-submersible platforms, namely the Ocean Ranger platform, offshore eastern Canada in 1982 with loss of the entire 84 man crew, and more recently in 2001 of the loss of P-36 (LON–004), offshore Brazil with 11 lives lost in the initial stages of the incident that led to eventual capsize and sinking. Subsequent to the loss of the Alexander L. Kielland the Norwegian Maritime Department adopted a 3-tier approach to stability standards, such that a unit should withstand the loss of buoyancy from either the whole or major part of one column. When considering such catastrophic failure, it is to key to ensure even in a failed state there remains sufficient time for an orderly evacuation from the damaged unit. The IMO MODU code was also updated in the aftermath of the loss, improving standards for stability, motion characteristics, manoeuvrability, watertight doors and structural strength of units. It is noted that a sister rig Henrik Ibsen suffered a jammed ballast valve shortly after the Alexander L. Kielland incident, and whilst listed by 20 degrees, was successfully righted.

Management of Change – The commission found the decision to convert the rig from a drilling function to an accommodation platform was made without a comprehensive risk assessment.

Regulation & Responsibility – At the time of the loss of the Alexander L. Kielland, nine different regulators had various regulatory responsibilities on the Norwegian continental shelf (NCS), with the Norwegian Petroleum Directorate (NPD) having only responsibility for the temporary accommodation on the vessel, and the main authority being the Maritime Directorate. In aftermath of loss of the Alexander L. Kielland, the NPD took overall responsibility for both fixed and mobile facilities. A new Petroleum Act in 1985 provided clarity as to the responsibility of Operators for safety, in which the regulator produced performance based regulations, and the Operator provided solutions to satisfy the requirements. In 2004 this regulatory responsibility was transferred to newly formed Petroleum Safety Authority Norway.

Life Saving Equipment (Lifeboats) –The lifeboat manual release mechanism didn't allow release on load, and this design compromised their launching during the incident, particularly in view of the severe heel of the rig after the initial column separation, with 3 of the lifeboats being crushed against the rig. At the time of the incident, there were 7 x 50 man lifeboats, and only two of those remained usable for evacuation, and launched with reduced occupancy, although they did pick up survivors who had jumped or fallen into the sea. It is now mandatory on the NCS to have 200% capacity for lifeboats on all facilities, and new legislation introduced regarding on-load release hooks on lifeboats on offshore facilities. It is reported that whilst there were liferafts on board, enough to accommodate 400 persons (20 x 20 men rafts), no one managed to operate the release mechanism. Some rafts did release due to the heel of the platform, and were used by a small number of survivors. A number of liferafts were released from the Edda platform, and some survivors swam to the Edda platform.

Life Saving Equipment (Survival Suits) – Very few of the crew had access to survival suits, and those available were not necessarily in the right locations. Most of those who survived where in the water for less than 30 minutes. Following the incident the Norwegian government made it mandatory for everyone offshore to have such a garment, with two per person available.

Safety Training - It is noted that at the time of the incident, only around one-third of those on-board had attended any formal safety training prior to boarding, and fewer still had received training in regards to offshore survival. Much of the safety training provided on board was in regard to lifeboat practice.

Emergency Response – The command structure offshore was considered flawed by the investigation, and led to delays in evacuation, albeit recognising the limited 'window of opportunity' to evacuate in view of the imminent capsize. This led to improvements in identification of a clear authority to order an abandonment. The incident, which promoted a massive search and rescue operation involving many countries around the North, also highlighted the need for proactive co-ordination efforts. It is also noted that the assigned stand-by vessel took almost an hour to attend the incident, and did not rescue any survivors, this in spite of it being written into the Emergency Response Plan that attendance to any facility in the field could be achieved in 20-25 minutes.

Root Causes

Equipment Failure				Human Performance				Other	
Repeat Failure		Unexpected Failure		Human Engineering		Training	X	Sabotage	
Preventive/Predictive Maintenance				Procedures		Management System	X	Natural Peril - Wind Storm	
Design	X			Communications		Quality Control	X	Other	
Equipment/Parts Defective	X			Immediate Supervision					

Lessons Learned

Shift in Process Safety Culture – In much the same way that the Piper Alpha (LON–001) caused a seismic shift in regulatory and operational practice on the UK continental shelf, the loss of the Alexander L. Kielland some 8 years earlier was a catalyst for significant change in the Norwegian Sector, affecting both the Regulator and Operators. Forty years later, the regulatory regime in the Norwegian sector remains one of the more progressive offshore regimes globally, and sets a high standard for to which many others follow and aspire. A loss of such magnitude and significance, with multiple causal factors, should always prompt such a shift in the aftermath of a thorough investigation.

Safety Critical Elements (Design & Construction) – The incident identified the lack of clarity of design and construction standards for connections to the rig columns as being a critical causal factor to the incident. It is essential that projects of this nature are supported by clear design and performance standards, including quality assurance and control to support construction activity, that recognise the concept of a safety critical element, with a zero tolerance to compromise exercised. During operational life there should be a structural integrity management system in place, which includes for regular inspection and analysis of critical structural joints, albeit recognising the Alexander L. Kielland was less than 5 years old at the time of the loss.

Safety Critical Elements (Risk Assessment) – Rig stability and buoyancy, in a distressed state, is key to the survivability of floating structure. In this regard design standards should be robust, and acknowledge the risk (albeit low probability) of severe damage or catastrophic failure of a (single) structural member. These should ensure survivability, and as an absolute minimum, allow orderly evacuation. In the event of deviation from the original design intent (in the case of Alexander L. Kielland designed as a drilling rig, but used as a floatel), then change management should be rigorous.

Regulatory and Operator Responsibility – It is essential to have clarity of a single point coordinating regulatory responsibility for offshore safety in a given operating region, and that ultimate safety responsibility (duty of care) lies with the Operator, referred to the Duty Holder in some offshore jurisdictions.

Emergency Response – The Alexander L. Kielland tragedy highlighted a number of lacking or inadequate emergency response barriers that contributed to the large loss of life. The incident highlighted the need for mandatory pre-boarding safety and survival training, which is now largely common to offshore operations globally. It further stressed the need for life saving equipment such as lifeboats; liferafts; and other forms of tertiary escape, to function as intended in the highly deviated environment of an incident. It also highlights the mandated requirement of survival suits (for cold water environments) in redundant supply. Equally important in parallel to onboard safety training and evacuation simulation, is the need for clarity of a trained authority offshore to initiate abandonment, and emergency response plans that adequately address the multiple agency response required in such circumstances.

References

1. OTC 4236 – Investigation of the Alexander L. Kielland Failure – Metallurgical and Fracture Analysis.

2. NOU 1981:11 Summary (English) of The Commission of Inquiry's report.

3. Health And Safety Executive RR 143 – Review of the Risk Assessment of Buoyancy Loss (RABL) project.

4. PSA Video - Lessons from the loss of the Alexander L. Kielland.