Airbus A320-231, G-DJAR

AAIB Bulletin No: 7/2002	**Ref: EW/C2000/6/4**	**Category: 1.1**
Aircraft Type and Registration:	Airbus A320-231, G-DJAR	
No & Type of Engines:	2 IAE V2500-A1 turbofan engines	
Year of Manufacture:	1991	
Date & Time (UTC):	10 June 2000 at 1333 hrs	
Location:	Over the English Channel	
Type of Flight:	Public Transport	
Persons on Board:	Crew - 6	Passengers - 176
Injuries:	Crew - Nil	Passengers - Minor
Nature of Damage:	Air conditioning duct and non-return valve damaged	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	N/R	
Commander's Flying Experience:	N/R	
Information Source:	AAIB Field Investigation	

History of the flight

Work had been carried out on the number 2 (right) air conditioning pack during the evening of 9 June. On the morning of the incident, the flight deck crew positioned the aircraft from Manchester to Gatwick and during the climb out from Manchester, the aircraft suffered a loss of pressurisation. Standard flight deck crew actions were carried out and the aircraft descended to a suitable flight level in order to continue the flight to Gatwick. On arrival at Gatwick, rectification action was carried out.

The aircraft was then prepared for a passenger flight to Palma, Majorca. Before departure, the commander briefed the cabin crew on the previous air conditioning system problems. The crew elected to adjust their normal cabin service procedures such that the minimum of catering equipment would be out of the galley stowages and the cabin service would not be commenced until the commander had confirmed that the pressurisation system was satisfactory.

Prior to the departure, the passengers had endured a delay of around 15 hours to their original flight time because of technical problems with another aircraft. Upon boarding, some passengers voiced concern over the serviceability of the aircraft. They were reassured accordingly by the cabin crew.

After an uneventful take-off, the commander elected to maintain a reduced rate of climb, around 1,000 feet per minute, and initially all of the pressurisation system indications on the flight deck were normal. Passing Flight Level (FL) 200, the commander selected 'Open Climb', which is the normal maximum climb power setting.

Passing FL 300, the commander heard a resonance, similar to that experienced during the previous sector just prior to the loss of cabin pressure. Again, a decompression occurred and the cabin altitude began to climb rapidly. The flight deck crew carried out the appropriate 'Cabin Pressure - Excess Cabin Altitude' procedure. This involved donning their emergency oxygen masks, deployment of the passenger oxygen masks and initiation of an emergency descent. A PAN call was made and, when the aircraft had been levelled at FL 100, a return to Gatwick was initiated. The maximum cabin altitude that was experienced was 14,000 feet.

A normal landing was carried out at Gatwick with the emergency services in attendance. The passengers were received into a dedicated airport reception area where they were cared for by medical staff, under the airport's casualty arrangements and passenger details were collated by the attending airport police unit.

Flight Data Recorder

The Flight Data Recorder (FDR) replay showed that the aircraft's altitude peaked at FL 286 and then immediately began to decrease. The aircraft levelled briefly at FL 280 but then started a rapid descent. Co-incident with the start of the rapid descent the cabin pressure warning parameter activated (cabin altitude above 9,550 feet). Some 4 minutes and 10 seconds later, at about FL 115 the aircraft's rate of descent began to decrease and it was level at FL 100 about 1 minute later. Generally the aircraft maintained an average descent rate of 5,000 feet per minute during the emergency descent. The cabin pressure warning ceased 7 minutes and 30 seconds after initial activation as the aircraft was descending further through FL 90.

Aircraft Environmental System and emergency oxygen supply

High pressure air is taken from each engine and ducted to a corresponding air conditioning unit ('pack') where its pressure, temperature and humidity are modulated. (Figure 1) Each pack is housed outside of the pressure hull in a compartment, which is protected against overpressure by a 'blow-out' panel. The 'conditioned' air is delivered into the pressure hull via a section of flexible ducting/bellows (reinforced polymer) and a Non Return Valve (NRV). The bellows (Part No.2157160000000) connects the pack condenser outlet to a rigid duct, which leads to the NRV at entry to the pressure hull. The bellows is normally retained by a V-band clamp at its forward end where a metal rim is integrated into the bellows to engage with the clamp. At its aft end the final, parallel section of the bellows is simply a sliding fit over the condenser outlet duct where it is normally secured by a metal, flat band clamp. The function of the NRV is to maintain cabin pressure in the circumstances of a single pack failure. Cabin pressure is controlled by an outflow valve, which modulates the rate at which air vents to the exterior from the cabin. The cabin condition can be controlled by an automatic system or by the crew manually. During the climb the system adjusts to control the rate of climb of the cabin altitude. In the cruise the system maintains a cabin altitude of less than 8,000 feet.

The passenger emergency oxygen masks are housed in the overhead cabin furnishings and can be manually deployed by the flight deck crew or will automatically deploy if the cabin pressure altitude increases above 14,000 feet. When the flap of the emergency oxygen mask compartment opens and the masks fall (in groups of up to four) each mask is suspended on a cord. All of the cords in a particular group are connected to a firing pin at the oxygen generator (canister) serving those masks. When a passenger pulls one of the masks to their face the pull on the cord will remove the firing pin and initiate the chemical reaction in the canister, which generates oxygen. The chemical reaction also generates heat and the canister becomes hot, giving rise to a burning smell. When the masks are initially stowed, the plastic tubes, which feed oxygen from the canister to the masks are coiled and stowed within the masks. To aid lubrication, stowage and deployment, french chalk dust is regularly used in the stowage process. As the masks drop and the tubes uncoil the masks tend to rotate and there can be some entanglement and some chalk dust is released. Part way down the tube from the canister there is a flow indicator; if oxygen begins to flow in the tube a green bead is pushed out of a recess in an opaque section of the tube and becomes visible through the translucent tube material. The pre-flight briefing of the passengers on the use of the emergency oxygen masks was provided, along with other safety instructions, by a video presentation which included the following sound track:-

> "IN THE UNLIKELY EVENT OF OXYGEN BEING REQUIRED MASKS LIKE THESE WILL AUTOMATICALLY BE PRESENTED FROM THE PANEL ABOVE YOUR HEAD AND IN THE TOILETS. REMAIN SEATED, REACH UP AND PULL THE MASK SHARPLY DOWNWARD, PLACE IT OVER YOUR NOSE AND MOUTH WITH THE ELASTIC AROUND YOUR HEAD AND BREATH NORMALLY. FOR PASSENGERS TRAVELLING WITH SMALL CHILDREN, FIT YOUR OWN MASK FIRST BEFORE ATTEMPTING TO ASSIST YOUR CHILD"

Following this incident the operator removed the word 'sharply' from 'pull the mask sharply downward' because of the problems encountered with passengers detaching masks from generators.

After the emergency descent the following announcement was made to the passengers by a member of the cabin crew:-

> "LADIES AND GENTLEMEN, THERE HAS BEEN A REDUCTION OF CABIN PRESSURE AND THE AIRCRAFT HAS DESCENDED TO A LOWER ALTITUDE. THE SMELL YOU MAY BE AWARE OF IS ASSOCIATED WITH THE NORMAL OPERATION OF THE OXYGEN GENERATORS"

The aircraft manufacturer has a customer system option available, which would automatically broadcast a PA message to passengers in the event that the oxygen masks are deployed. Such a system was not fitted to G-DJAR.

Examination of Aircraft

In an examination of the aircraft after the event, it was found that the No 2 pack, air conditioning bay blow-out panel was displaced, indicating a bay overpressure event. The flexible bellows section in the outlet ducting of the pack was found disconnected at its aft end (the end usually connected with the flat band clamp), which is the upstream end in terms of the airflow from the pack. (Figure 2) The detached end of the bellows was damaged and frayed, its walls were chafed and had split in places allowing some of its internal reinforcing fibres to protrude. Its condition

indicated that it had been damaged by rapid fluttering and axial compression of its convolutions. It was the duct's aft fitting which had been the subject of the repair carried out before the flight.

The NRV at entry to the pressure hull was also found damaged. It is a simple flap valve normally held closed by a light spring. The flap was broken roughly across its diameter and approximately half of it was missing. The fracture surfaces all indicated an overload mode of failure and the remaining part of the flap was slightly deformed in a manner which indicated that it had been slammed against the flexible 'open' stop, which normally contacts the centre of the circular flap of the valve. The distribution ducting and plenum chamber were searched but no fragments of the valve flap were found. One small fragment was found in the under-wing fairing, within the bay which accommodates the pack. This section exhibited a witness mark where it had contacted the 'open' bump stop and it had also been made concave by the impact. Its position suggested that the other fragments had also been expelled outward by cabin air through the open end of the duct and had probably been lost through the 'blow-out' panel that had opened in flight. This was consistent with bellows detachment preceding the failure of the NRV.

It was concluded that the bellows had detached at its aft end and had been subjected to violent oscillations by the airflow out of the pack, possibly exacerbated by the duct occasionally partially re-engaging on or at least re-aligning with the pack outlet and being blown off again.

As the aircraft had suffered a loss of cabin pressure on the previous flight it seems certain that the NRV had actually broken during that earlier event. It seems likely that the oscillation of the bellows after it detached on the positioning flight, as well as the competing air flows from the pack and the pressurised cabin, produced severe flow and pressure fluctuations in the downstream part of the duct to the NRV. This resulted in the flap of the non-return valve slamming open and shut causing it to break. This sequence is consistent with symptoms consisting of a loud noise and vibration as described by the crew.

Maintenance History

Maintenance on the aircraft was carried out by a specialist company, contracted by the airline. Relevant items in the aircraft's maintenance history appeared to date back to July 1998, when a repair was recorded as being carried out to the No 1 pack flexible duct. The nature of this repair is not known but a following entry noted that the, "ducting appeared to hold OK". Four days after the first entry the flexible duct (Part No. 2157160000000) was recorded as being replaced. In September 1998 a defect entry recorded that the No 2 air conditioning pack outflow duct was split. An order was placed for a new duct and an unspecified temporary repair carried out. Three days later a new duct was installed. Subsequently there were several entries in the technical log involving the No 2 pack but none directly mentioned the flexible duct.

On 6 June 2000 an overheating problem was reported on the No 2 pack. A BITE (Built In Test Equipment) check and a ground run found no fault. On 7 June 2000 the No 2 pack condenser, which had a cracked flange, was replaced and this involved the disconnection and reconnection of the flexible duct at the condenser outlet. The engineer who carried out this work while the aircraft was on a three hour 'turn round' found that the duct was held on the condenser outlet by a nylon tie-wrap and he replaced 'like with like'. Though he had some doubts about whether this was the correct attachment method he became involved with handing over to the next shift after he had completed the job and he did not pursue the matter or raise a 'Deferred Defect' to have it replaced or monitored. In flight, following the condenser replacement a low frequency vibration was reported during the climb and the No 2 pack overheated several times in the cruise. After flight, the (non-

pressurised) air-conditioning pack compartment overpressure (blow-out) panel was found open. The No 2 pack was disabled, the exhaust door and its actuator being removed due to a structural fault.

Although the pack was disabled, in the following three days there were three cases reported of the air conditioning bay overpressure panel being found open. This may have been due to leakage at the No 2 pack flexible duct, which was pressurising the bay (perhaps from the cabin) or from other leaking seals in the pack ducting which were later identified. Functional checks and leak checks were carried out on the No 2 pack during this period.

On 9 June the aircraft arrived at Manchester with a report in the Technical Log that the No 1 pack had overheated on the ground at Naples. The engineer tasked with rectifying the fault asked for additional 'down time' in order to investigate this and another fault. BITE and functional tests of the No 1 pack showed it to be serviceable and so he worked to re-instate the No 2 pack by installing a new exhaust door and actuator.

The following flight was the ferry flight from Manchester to London Gatwick during which the aircraft suffered a loss of cabin pressure. This event was less severe than the subject incident with a descent being initiated from FL 190. A loud pulsing noise was heard and, though the cabin pressure initially held to a normal profile with outflow and safety valves closed, the cabin altitude later developed a rate of climb of 2,000 feet/minute and an emergency descent was initiated. The aircraft was reported unserviceable at Gatwick and the Captain made a Technical Log entry as follows, "A/C FAILED TO PRESSURISE. ALL ECAM IND(ICATION)S (ALL PAGES) NORMAL." Subsequently, he gave a fuller (and more accurate) description of the rapid depressurisation in a Flight Safety Report but the engineer who undertook the rectification at Gatwick only had the Technical Log entry for reference and did not have an opportunity to talk to the crew.

The engineer had been working on and deeply engrossed in an engine defect on another aircraft and was called from that job to investigate and rectify G-DJAR. An airline liaison engineer, who had been involved in the work on the other aircraft accompanied him. While he was working on G-DJAR he was interrupted by questions about the other aircraft. He found that the No 2 blow-out panel had deployed and the flexible duct had detached and was in poor condition. He could not find the metal flat band clamp that should secure the aft end of the duct but a nylon tie-wrap had fallen out as the access panel was removed to gain access to the duct. The size and curvature of the tie-wrap fitted the bellows end. He found that neither the duct nor the flat band clamp were available in store at Gatwick and the airline liaison engineer asked whether a temporary repair could be carried out; the airline was having severe scheduling difficulties due to several aircraft having become unserviceable.

The maintenance engineer, with the help of a mechanic, undertook to attach the aft end of the duct using glass-fibre reinforced adhesive tape and two tie-wraps. This produced what appeared to be a much more secure arrangement than that which had previously been in place. Such a repair was outside the approval authority of the engineer and it should have been considered by the maintenance company's Main Operations Control (Maintrol) and an engineering concession obtained. Maintrol was contacted by telephone but the personnel at Gatwick were advised that no one at Maintrol would take responsibility for such a repair. Neither did Maintrol take any action to prevent the aircraft being returned to operation with this repair. The engineer and other personnel at Gatwick were confident in the security of the repair and, after carrying out a functional and leak check, the engineer signed the Certificate of Release to Service in the Technical Log. The leak

check, using the Auxiliary Power Unit for power and air, did not constitute a full pressurisation test and the duct was not, therefore, subjected to full pressure differential.

The NRV must have been damaged at this time to allow the loss of cabin pressure when the bellows detached. However, it did not occur to any of the personnel involved, either at Gatwick or Maintrol, that detachment of the flexible duct from one pack should not have resulted in a loss of cabin pressure or a failure to pressurise, as described in the Technical Log. The NRV should have closed off the outflow from the cabin leaving it pressurised by the No 1 system. The failure of the NRV was, therefore, not discovered.

In the post-incident inspection two trim air valves in the system were found damaged but this is considered to be probably secondary to the flexible duct disconnection and not contributory to the decompression.

Passenger Cabin Events

The flight to Palma was to have departed at 2230 hrs on the previous evening but it was delayed when the aircraft programmed to conduct the flight became unserviceable at another airport. By 0030 hrs it had become apparent that there was going to be a delay until the next day, so the passengers were accommodated overnight in a local hotel.

They then returned to the airport for 0900 hrs the following morning. There was then a further delay and the flight did not board until about 1300 hrs. Passengers complained that, while waiting, they were given conflicting or erroneous information by ground staff and the airport information system.

One Passenger reported that when he arrived at the departure lounge there were a large number of passengers around the desk and the police were present. After they were on board there was some further delay and the aircraft finally departed at 1320 hrs.

The flight deck crew had ferried G-DJAR from Manchester and had experienced the loss of pressurisation on that flight. The commander briefed the cabin crew, who had not experienced that event, in case there should be a recurrence. He told them that he would monitor the cabin pressure and maintain a reduced climb rate until it was assessed that the pressurisation was normal.

When boarding G-DJAR some passengers asked ground staff and cabin crew questions about the serviceability of the aircraft and were given reassuring answers. Two reported that they had heard that an aircraft had had problems when flying down from Manchester on the previous evening and were told, specifically, that it had not been this aircraft.

Following the incident, a number of passengers contacted the AAIB to express concern about what they had experienced during the incident and about the operation of the emergency oxygen equipment in the cabin. It was decided to contract the Human Sciences Centre of DERA, Farnborough, to collate all of the passenger information. A questionnaire was circulated to the passengers and those returned were analysed.

The questionnaire was sent to 144 adult passengers and 106 were returned. Respondents ages ranged between 16 and 66 years with an average of 35 years and 49% were male. All had significant flying experience (more than 5 flights) and a large proportion were experienced airline

passengers (41% having flown on more than 21 occasions including 7% who reported more than 100 flights).

Passengers had varying recollections of the pre-flight video safety briefing. The majority recalled that, if the cabin lost pressure, then oxygen masks would drop, that they should be pulled to activate and fitted over the head. Recollection was weaker (20 to 30%) on the topics of securing the mask (pulling the elastic band tight), fitting one's own first before helping others and breathing normally once the mask had been fitted. 62% also read the safety briefing card but their recollection of the points which were included on the card was much weaker.

For most of the passengers, the unannounced deployment of the emergency oxygen masks was the first indication that something was wrong. A large minority (40%) were alerted by changes in cabin pressure (ears 'popping'), aircraft motion (initiation of descent) or change in ambient noise but whether this was generally before or after mask deployment is not clear. 22% said that cabin crew had informed them.

Two cabin attendants sensed the loss of cabin pressure and, having previously been alerted to the possibility, immediately stowed the service carts back in the galley. As the last cart was being stowed, the oxygen masks deployed. Initially the cabin crew donned their oxygen masks and called to passengers to do the same. One saw that some passengers were simply staring at the masks and she shouted at them to grab a mask.

Passenger descriptions of the situation in the cabin varied; some indicated that there were signs of panic or were crying and there was some shouting but one cabin attendant and one passenger reported that, to them, the passengers appeared to remain calm. Some passengers noticed one cabin attendant who was upset and crying.

When the commander gave permission, the four cabin crew donned their portable oxygen supplies and began to move around the cabin assisting passengers, particularly families with children and those who were visibly upset. It was difficult to ensure that the children kept their masks on as some were afraid of the mask as it covered most of the facial area.

Two people vomited and, later, after landing, an infant vomited. As the aircraft taxied in after landing, one passenger, who had earlier been abusive to cabin staff, lit a cigarette. This was removed by a cabin attendant. After the passengers had disembarked he was again rude to the crew and was seen to vent his anger by kicking the aircraft steps. A policeman who was nearby was called to speak to him.

Some 28 of the respondents commented on the cabin crew's response to the incident. Although 12 considered that they had failed to offer adequate assistance to the passengers and others stated that they appeared uncertain as to how to respond to the depressurisation, 10 were complimentary about the assistance and reassurance that they had received.

The cabin crew had some difficulties with the emergency oxygen masks; a crew mask in the rear galley had its face strap wrapped around the mask and bag which had to be untangled before use and the crew masks at Doors 2 did not deploy.

The concerns of the passengers centred on three issues; uncertainty about the supply of emergency oxygen, the fitting and securing of the oxygen masks and the lack of information or advice in the initial phase of the depressurisation. Most passengers recognised that the flight crew were fully

occupied at that time and the cabin crew, wearing oxygen masks, were not able to use the public address system. The lack of a reminder about the emergency oxygen masks and about details of its operation probably contributed to the difficulties, perceived and real, that the passengers experienced.

Some 95% of responding passengers reported that they lacked confidence in the operation of the emergency oxygen system and 76% that they had experienced difficulty in using the system. Some passengers were disturbed by the release of dust, which had gathered on the inside surface of the mask stowage panel, by the entanglement of the masks and tubes, by the brown colour of the lower section of the delivery tube and by the pungent smell created by the hot canisters. Some reported that the masks appeared dirty or dusty.

Their principal concern was about the adequacy of the rate of oxygen flow. Though some could hear a hissing sound they had little sense of oxygen flowing into the mask and many doubted whether the oxygen was flowing because the bag reservoir did not inflate. The behaviour of the bag will depend on the oxygen flow rate but also on the ambient pressure and the rate of breathing of the wearer. One passenger (having donned his mask) was aware of the people around him breathing deeply. One passenger reported that the bag remained as flat "as if he had sat on it". Some of the passengers who felt that they were not getting any flow pulled on the tube itself and a few pulled the tube off the canister. As cabin staff moved around the cabin, they checked the flow indication for some of the passengers; four passengers reported that the flow indicator did not show that oxygen was flowing.

28% of the responding passengers said that they had problems fitting or securing the masks to their faces. Only slightly less than half of the respondents said that they assisted someone else with their mask. Most of these (37 out of 49) said that they helped only after donning their own mask. Three had difficulties in providing assistance because they had been unable to secure their own masks and were holding them in position. The strap on the mask is elastic but is only loose fitting initially and the strap ends at the mask have to be pulled to tighten it around the person's head.

82% of respondents reported physical symptoms that they had suffered as a result of the incident. A majority (55%) reported ear pain. The AAIB was told early in the investigation that some people had suffered perforated eardrums but this was not confirmed in the survey responses. Some people did suffer short term hearing loss.

A large number of passengers (53) reported symptoms (shortness of breath, weakness, numbness or tingling sensations) which could be associated with hyperventilation or anxiety arising out of the emergency. 43 respondents reported headaches. 13 complained of chest pain and 5 experienced joint pain.

Given that the maximum cabin altitude achieved during the incident was 14,000 feet for less than five minutes, the likelihood of anyone suffering the effects of hypoxia (lack of oxygen in the bloodstream) were probably limited to those passengers who were heavy smokers, obese or otherwise physically unfit.

Previous incident

In June 1995 a Lockheed L1011-385-1-14 Tristar, registration G-BBAH (AAIB reference EW/A95/6/1 reported in Bulletin No 2/96) en-route from Manchester to Tenerife suffered a rupture of the rear pressure bulkhead leading to a rapid decompression of the cabin. Passenger oxygen

masks were deployed and a pre-recorded emergency descent announcement was automatically activated. During the subsequent diversion to Faro some passengers became concerned with the smell of burning associated with the chemical oxygen generators.

As a consequence of this incident the AAIB made the following recommendation:

> **Recommendation 95-39**: The CAA and FAA should consider recommending amendment of passenger briefings broadcast after emergency oxygen mask deployment to include reference to the possibility of smells of burning produced by the normal operation of associated oxygen generator systems, where applicable.

In response the CAA, in their Notice to AOC holders (NTAOCH) No 5/96, recommended that:

> 'as soon as practicable after emergency oxygen masks have been deployed, passengers should be advised that there is a possibility of a smell of burning associated with the normal operation of chemical oxygen generator systems.
>
> Operators of aircraft that have chemical oxygen generator systems should review and amend their post-decompression procedures and public address announcements accordingly. Such information should not apply to the normal pre-flight briefing of passengers, and should only be announced in the event of an actual decompression.'

Discussion

The defects reported on the aircraft the previous day were inappropriately addressed by maintenance. Such trouble shooting as there was failed to detect the No 2 conditioning pack NRV damage and the condenser outlet duct was reconnected using an unapproved technique. This resulted in the duct again becoming disconnected and a subsequent loss of cabin pressurisation. There were some mitigating circumstances in that the individuals were under considerable pressure to return the aircraft to service and the requisite spares were not available.

The maintenance company's internal investigation concluded that there had been significant deviations by staff from laid down internal procedures and a failure of the engineering management organisation to support line staff. It also found that the company's Reliability Monitoring System had failed to highlight the recurrent problems with the No 2 air-conditioning pack. It recommended that all staff at Gatwick be briefed on the limits of their authority and the concession procedure.

The passengers had suffered a 16 hours delay to their departure, having spent the night in a Gatwick hotel, and during the delay at the airport they had not been kept updated on their likely departure time. Some later felt that they had been mislead about the maintenance status of the aircraft when they had enquired whether it was the aircraft that had suffered some defects the previous day.

The cabin altitude peaked briefly during the event at 14,000 feet and was above 9,000 feet for some 7 minutes and 30 seconds. This would not have constituted a serious health threat to a medically fit person but was undoubtedly a period of confusion and distress to many of the passengers. Although most were aware of some of the information from the pre-flight safety briefing video for most the details were forgotten. The deployment of the oxygen masks, some tangled, and the smell of the hot oxygen generators coupled with confusion on the use of the masks and a lack of confidence in the system performance created for some a state of high anxiety. In the absence of the Airbus

automatic message, an early PA announcement to re-assure the passengers and redefine the use of the oxygen system and its performance would undoubtedly have helped matters.

It is therefore recommended that:-

Recommendation 2002-5

The CAA should bring to the attention of AOC holders and the JAA, the circumstances of this incident and the advantages of using the 'Pre-Recorded Announcement' (PRA) facility when it is provided as a manufacturers' option. Furthermore the CAA should recommend to AOC holders that they should review their post decompression procedures and, where appropriate, introduce a public address announcement.

Recommendation 2002-6

The Central JAA should review the adequacy of the requirements detailed in JAR-OPS 1.285 for the briefing of passengers and in particular the requirements relating to the provision of 'picture type instructions' indicating the operation of emergency equipment and the demonstration of the use of oxygen equipment, and amend as necessary.