# MINUTES OF MEETING

**TAKEN BY:** Jessica Hannigan / Nik Pagerly
**DATE:** 7/17/2007

**Meeting led by Albert Murrer:**

Everyone is aware of the $CO_2$ problem that DS had in the TBM three weeks ago when departing LZU. Until recently, the assumption has been that the problem was directly related to the large volume of bags in the a/c blocking airflow and the quantity of dry ice that was onboard. We have researched similar incidents of $CO_2$ poisoning and we are developing tools to raise awareness among the group in order to avoid future recurrences.

AM had an incident last week while departing TEB in a TBM carrying 8 bags, only 2 of which contained dry ice. Weather was down and the airport was busy so it took a long time from the point where the a/c was loaded and closed up until it was time for start and taxi. During this time, he experienced disorientation and shortness of breath which he attributed to his rushing around to load the a/c and simply being out of shape. The oxygen tank and mask were not easily attainable at this time and the door had to be opened several times to allow airflow into the cabin. It wasn't until after startup when the bleed air was turned on that he realized his condition was probably caused by the presence of the dry ice. This points to the fact that whenever dry ice is carried aboard an a/c, pilots must be highly aware of proper airflow management.

**New Policies:**

Oxygen Bottle:
In order to ensure that the oxygen bottles are available and usable if needed, their postion in each a/c type will be standardized. In addition, each pilot as a preflight action will complete the following:
1) Ensure that the bottle is in its approved position.
2) Ensure that the bottle is full.
3) Clean the mask with a disinfectant wipe.
4) Inspect the lines to the mask and perform an operational check.

A/C Procedures:
A/C specific procedures will be determined in the near future.
Note: Crews should maintain a positive fresh airflow at all times whenever dry ice is being transported.

**Action Items:**

Scott has purchased disinfectant wipes to put in all a/c to wipe down the masks. Some will be sent to LZU tonight, with additional bottles to follow when the rest of them arrive. In the Barons and 310s the wipes will be kept in the glove box, in the TBM they will be in the center console area. Pilots should be diligent about removing waste from the a/c after each flight.

# Carbon Dioxide Awareness Training

**Please read the following information**

**The enclosed Quiz must be completed and returned to Nik Pagerly in RDG no later than**

**SEPTEMBER 12, 2007**

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# Carbon Dioxide Considerations for Quest Air Pilots

**Definitions**

- **Dry ice**: Solidified carbon dioxide ($CO_2$).
- **Carbon Dioxide**: A colorless odorless gas that is a natural product of animal and human respiration and other energy releasing processes
- **Sublimation:** The process of converting a solid substance (such as dry ice or solid $CO_2$) into a gas ($CO_2$ gas).

**Why is it important to know about dry ice transported aboard our aircraft?**

Dry ice sublimates to gaseous $CO_2$ at normal aircraft environmental temperatures. Excessive $CO_2$ gas in the aircraft can cause crew incapacitation. Dry ice is generally carried aboard our aircraft to keep biological substances frozen. The quantity of dry ice on our aircraft may vary according to the amount of material tha must be kept frozen, the shipment time, the insulative nature of the packaging, the desired temperature of the shipment or other considerations.

Dry ice is classified as a hazardous material under 49 CFR. In addition, gaseous $CO_2$ that can result from sublimation of dry ice and other sources is regulated under 14 CFR. Dry ice sublimation producing excess $CO_2$ gas may be dangerous in confined spaces where there is an absence of ventilation or ventilation rates are low. The conversion rate of dry ice to gaseous $CO_2$ will vary depending on package insulation, dry ice particle size, surrounding temperature and cabin pressure.

Tests conducted by Pan American Airlines in 1963 indicated that a sublimation rate of one pound per hundred pounds of dry ice per hour (1%/hour) could be expected for packages containing 100 lbs of dry ice. More recent tests conducted by the FAA demonstrated that the sublimation rate for small insulated shipping packages containing 4.6 to 5.3 lbs of dry ice averaged 2%/hour. In these tests 5 lbs of dry ice in pellet form (identical to the dry ice that Quest uses when shipping frozen specimens), was added to each of 20 pre-weighed ThermoSafe shipping containers. The boxes were then weighed to establish their 'pre-flight" weight and placed in an altitude chamber. The chamber was then depressurized to an altitude of 8000 ft MSL at a rate of 1000 ft/minute. The total time of the simulated flight was 6 hours. The containers were then removed and immediately weighed to obtain their "post-flight" weight. Using the differences in weight as well as the total flight time, an average sublimation rate of 2.0 +/- 0.3% per hour was determined. These results indicate that the rate of sublimation is greater when the dry ice is packaged in pellet form in small quantities (greater exposed surface area = greater rate of sublimation)

Historically there have been very few reported incidents of carbon dioxide incapacitation aboard aircraft attributed to dry ice sublimation. In the incidents that have been reported, the aircrew recognized the symptoms and took appropriate measures to avoid any serious problems.

Modern pressurized aircraft reprocess or re-circulate a portion of their cabin air. Even though the re-circulated air passes through filters, these filters do not remove very small molecules such as $CO_2$. Even with recycled air, a properly functioning modern pressurized aircraft environmental control system provide fresh air for a substantial number of complete cabin air exchanges per hour, making buildup of carbon dioxide in the cabin an unlikely event. If aircraft ventilation is not effective, a buildup of $CO_2$ could occur.

**What are the physiological effects of carbon dioxide?**

The National Institute for Occupational Safety and Health (NIOSH) categorizes carbon dioxide is as a simple asphyxiate with symptoms resulting only when such high concentrations are reached that the gas affects the brain and other physiological functions. The signs and symptoms of $CO_2$ poisoning are similar to those that precede lack of oxygen, namely headache, dizziness, muscular weakness, nausea, drowsiness and ringing in the ears. $CO_2$ poisoning does have a greater effect on breathing than simple lack of oxygen, causing a significant increase in the rate and depth of breathing as an early symptom. Removal from exposure results in rapid recovery.

Exposures to $CO_2$ in aircraft should not exceed a sea level equivalent to 0.5% $CO_2$ (5000 parts of $CO_2$ per million parts of air or 5000 ppm). 5000 ppm is also used by the Department of Labor, Occupational Safety and Health Administration (OSHA) as an 8-hour time weighted average permissible exposure limit (PEL) I general industries. Production of symptoms is related to the effect of increased $CO_2$ on certain bodily processes. No symptoms occur from the inhalation of $CO_2$ if the atmosphere contains only slightly more than the normal amounts of $CO_2$. When the concentration of $CO_2$ approaches 2%, the depth of respiration is increased so that the amount of air into the lungs with each breath increases up to 30%. If the concentration of $CO_2$ is as high as 4%, there is not only an increase in the depth of respiration but also an increase in the rate of respiration.

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At this point, breathing is deeper and somewhat faster and considerable discomfort is produced. A CO2 concentration of 4.5-5% causes breathing to become extremely labored and almost unbearable in some individuals. The highest concentration of CO2 that can be tolerated is 7-9%. More than 10% can cause loss of muscle control and unconsciousness.

**What are the hazards associated with dry ice?**

The hazard associated with the carriage of dry ice aboard all aircraft is considered to be minimal under normal cabin ventilation conditions. However, in the absence of proper ventilation, the sublimation of dry ice could result in unacceptable levels of CO2 in the cabin environment.

**What are the precautions and recommendations for the transportation of dry ice aboard aircraft?**

***Maintaining adequate input and circulation of fresh air is the single most important precaution that must be taken when dry ice is transported.*** Additionally, the aircrew should be aware of the hazards involved in the transport of dry ice and they should be prepared to take execute appropriate emergency procedures if required. Emergency procedures should include instructions that if symptoms occur or if a buildup of CO2 is suspected, the use of emergency oxygen should be initiated immediately. When packages containing dry ice are onboard an aircraft, which is not under power on the ground, the doors and windows, should be open in order to allow sublimate gas to escape. When powered ventilation is not available it only takes a small amount of dry ice to produce an unacceptable level of CO2 in an aircraft.

**Estimating dry ice limits an sublimation rates**

The amount of dry ice that can be transported relative to the volume of fresh air circulation in an aircraft can be calculated.

The dry ice sublimation rate will depend on the amount of dry ice stored in a package, the packaging of the dry ice, the form of the ice (block or pellet), and numerous other variables. The experimentally determined sublimation rate for large (100 lbs) amounts of dry ice per single package is 1% per hour. The experimentally determined sublimation rate for small (5 lbs) amounts of dry ice per single package is 2% per hour. One pound of dry ice sublimates to produce 8.5 cubic ft of CO2 gas. Thus, a sublimation rate can be defined as X cubic ft of CO2 gas per hour. A dry ice sublimation rate of 1% per hour provides 8.5 cubic ft of CO2 gfas per hour. A 2% per hour sublimation rate provides 17 cubic ft of CO2 gas per 100 lbs (e.g., 20 X 5 lb packages) of dry ice per hour.

The following formula then provides a rule-of-thumb for dry ice loading relative to the volume of air circulation. Examples are provided for both 1% per hour and 2% per hour sublimation rates.

Where X = Dry ice loading in lbs:

$$X = \frac{\text{(CO2 concentration) (Aircraft volume, cubic ft) (Complete air exchanges per hour*)}}{\text{(Sublimation rate)}}$$

Example 1:

Aircraft volume: **5000 cubic ft**
Complete air exchanges per hour: **20**
Allowable CO2 concentration (TBVL, .5%): **.005**
Sublimation rate of 2% per hour ((2 x 8.5 cubic ft CO2)/100 lbs dry ice/hour): **.17**

$$X = \frac{(.005)\ (5000)\ (20)}{(.17)}$$

X = 2941 lbs of dry ice

* Note: Newer models of airplanes may recycle as much as 50% or the cabin ventilated air, instead of providing 100% fresh air as older models of aircraft did. This is the reason that the number of complete cabin air exchanges of fresh air is required to determine the amount of dry ice that can be safely transported.

(3) **Quest Air data**

Drager Tubes were used to collect data from our aircraft over a two-month period. The Drager Tubes determine the average concentrations of $CO_2$ that are present over a period of time. A formula is used to determine the average ppm exposure (tube reading/hours). The results from this testing are presented below:

| Date | A/C Type | Start Time | End Time | Total Time | Tube Reading | PPM |
|---|---|---|---|---|---|---|
| 06/27/06 | TBM | 1845 | 0245 | 8.0 | 15000 | 1875 |
| 06/30/06 | Baron | 1730 | 2300 | 5.5 | 10000 | 1818 |
| 07/06/06 | Baron | 1100 | 0245 | 3.7 | 5000 | 1351 |
| 07/07/06 | TBM | 1845 | 0245 | 8.0 | 10000 | 1250 |
| 07/12/06 | TBM | 1900 | 0315 | 8.3 | 10000 | 1205 |
| 07/17/06 | Pilatus | 2030 | 0330 | 7.0 | 13000 | 1857 |
| 07/18/06 | TBM | 1930 | 0330 | 8.0 | 15000 | 1875 |
| 07/21/06 | Baron | 1930 | 2152 | 2.4 | 15000 | 6000 |

**Conclusions specific to Quest Air**

The studies that were undertaken by the FAA used as a model large cargo type aircraft whose cargo areas are 1000's of cubic ft in volume. The question then becomes how do we apply this data to our particular situation?

Similar calculations can be made for our aircraft to determine what is the maximum amount of dry ice that we should carry. This information, used in conjunction with the information obtained from field testing, will then allow our operation to develop the best possible policies and procedures regarding the transport of dry ice.

According to data obtained from Drager Tube testing, the normal exposure experienced by our pilots is within the limits set by the Federal Standards (5000 ppm). One test resulted in an elevated exposure indication; but this may itself be an anomaly, as that value has not been supported by any similar results. The results posted on 7/21/06 may also have been caused by airflow mismanagement. It is possible that the ventilation may not have been operated properly or the aircraft may have been allowed to remain closed up for a length of time.

The result of this investigation illustrate that pilots are being exposed to $CO_2$. It also indicates that if they maintain their awareness regarding the effects of carbon dioxide and take proper measures to reduce their exposure, the transport of packages containing $CO_2$ can be done safely.

**Specific procedures to mitigate the effects of CO2**

***Airflow, Airflow, Airflow!!!***

Because the level of carbon dioxide can increase rapidly in small aircraft like ours, pilots need to constantly be aware of methods that can reduce and otherwise control this buildup. Simply stated, it is necessary to ensure that the air in the cockpit is being exchanged as much as possible.

When the aircraft is loaded and stationary on the ground, it should not be closed up any more than is necessary. Doors and windows should remain open as long as possible before starting the aircraft.

During taxi, non-pressurized aircraft should operate their cabin fan or crack the door (depending on weather). Pressurized aircraft should operate their bleed air on high. If engine temperature is an issue, bleeds can be operated on low if necessary until reaching a point in the flight where the bleed can then be switched to high. It may be necessary for pilots to utilize supplemental oxygen for those periods when the airflow is reduced. In addition pilots should not operate the air-conditioning system in pressurized aircraft without also operating the bleed air. The air-conditioning systems in our pressurized aircraft re-circulate air in the cabin and do not introduce sufficient volumes of fresh air.

After take off in non-pressurized aircraft pilots should continue to maintain the maximum amount of airflow possible using both vents and circulating fans. In our pressurized aircraft pilots should operate bleeds on high.

Throughout the flight, supplemental oxygen should be used immediately if a pilot feels that they are beginning to experience any of the warning signs that $CO_2$ may be affecting them. **Remember: because CO2 poisoning can affect a person's judgment, it is important that you act quickly and utilize oxygen at the first indication of any impairment.**

# FATIGUE AWARENESS TRAINING

# JUNE 2007

**Nicholas Pagerly**
**Flight Operations Safety Officer**

## Introduction

While we at Quest Diagnostics Flight Operations are not bound by any specific regulatory requirements regarding rest and duty times, operator fatigue is a critical safety issue that we must consider. Fatigue induces drowsiness, sleepiness and decreases the ability of workers to operate safely therefore increasing the risk of accidents and incidents.

The NTSB has found that the incidence of fatigue is usually underestimated in almost every mode of transportation. This is because fatigue is difficult to quantify and therefore difficult to measure by most normal methodologies.

Recently fatigue and its associated effects have been mentioned by crewmembers in reference to some of our flights. Of particular concern are those flights that involve a crewmember transitioning from a "daylight" schedule to a late night – early morning schedule over a two-day period.

Proper management of fatigue can be challenging given the limitations of time and the fact that our schedule runs opposite to what is considered "normal" for most humans. The following information is meant to re-enforce the training that all crewmembers received either in 2006 or, in the case of new hire personnel, during their initial training.

## Circadian Rhythms

"Circadian Rhythm" is best described as "the daily fluctuations in physiological and psychological functions controlled by the brain's biological clock". An individual's normal sleep/wake cycles are largely based on their circadian rhythm.

This rhythm leads to predictable changes in the level of an individual's alertness. Circadian rhythm is also tied to external time clues such as sunlight level and activity patterns.

Work schedules that require people to be awake at night and sleep during the day are challenging primarily due to circadian rhythm considerations. It is difficult for people to adapt to work schedules that are opposed to their circadian rhythms. This is due to the fact that the normal patterns of light and dark and the daily activity level stay the same. Further compounding the problem is the fact that shift workers often abruptly switch from one activity/rest pattern to another (like on weekends) in order to align with the rest of the "normal" world.

The end result is that if a person's circadian rhythm is not correctly aligned with an individual's work/rest schedule, their on-the-job alertness will potentially be affected.

## Operational Fatigue Risk Factors

During interviews with individuals from many forms of transport, several general operational fatigue risk factors were identified. These include:

- Extended work or commuting periods
- Split-shift work schedules
- Sleep/work periods conflicting with circadian rhythms
- Changing or rotating work schedules
- Unpredictable work schedules
- Lack of rest or nap periods during work
- Sleep disruption
- Inadequate exercise opportunities and poor diet
- Environmental stresses

### Split-Shift Work Schedules

Split-shift work can result in operator fatigue by resulting in schedules that are not conductive to obtaining adequate sleep during the normal rest period. Primary factors include:

- Early morning start of shift
- Late evening start of shift
- High paced operations during the work period
- Limited time at home during the awake period
- Difficulty in taking advantage of mid-day sleep opportunities

### Sleep/Work Periods Conflicting With Circadian Rhythms

The quality and quantity of sleep suffer whenever workers are forced to obtain their sleep during the time when they would normally be awake. Certain periods have been identified as "low" periods of circadian rhythm (approximately form 0100-0400 and from 1300-1600). These periods have been proven to be associated with drowsiness and a low level of alertness.

Difficult times to obtain sleep include:

- Late morning (if the individual is adjusted to a night-time sleep schedule)
- Afternoon (if the individual is adjusted to a night-time sleep schedule)
- Early evening (if the individual is adjusted to a night-time sleep schedule)
- Any shift in sleep due to travel across time zones that requires sleep during the day at the origin of travel (Jet Lag)

#### A Quest Air Example:

On their first day of duty, pilots who fly the 640/650 flight to Texas report at 4pm and end in Texas at 1am. The pilot is then not scheduled to report for duty again until 10pm the evening of the second day. The fact that the schedule shifts abruptly from daytime to nighttime makes it difficult for the pilot to properly schedule their sleep periods.

It makes sense to ease your way into this shift change by trying to stay up later the night of arrival and sleep longer into the morning. Many pilots report that they plan to wake up at 10 or 11 am, exercise or run errands, then eat a light meal. At this point they plan on being back in the room no later than 4 or 5pm in order to get a long nap immediately before they report for duty. This nap should be 3-5 hours in duration and because is longer than a normal nap allowance must be made to plan time in which the individual can overcome any sleep inertia and fully awake before reporting for duty. Therefore plan to wake from this nap no later that 1-hour before your scheduled report time.

### Sleep Disruption

When sleep is interrupted it has been proven that it is much more difficult for an individual to return to sleep. Some general factors that disrupt sleep for commercial transport workers include:

- Noise, vibration, movement, uncomfortable temperature and por air quality in sleeping quarters
- Unfamiliar environments with less than optimal conditions for rest
- Attempting to sleep at times which are contrary to one's circadian rhythm
- Sleep at home or away during normal waking hours can be disrupted by inadequate light shading, normal daytime noises, and inferior room air and temperature controls.

Some suggestions recommended to effectively combat these disruptions include:

- Use of earplugs to combat extraneous noises
- Make sure that the room temperature is comfortable – cooler with adequate airflow is normally best. Adjust available air-conditioning/fans or heat accordingly.
- Reduce the amount of light in your sleep area using dark window shades or an eyeshade.

**Technicians**

As is the case with our pilots, other than the policy set forth in our FOM, our Technicians have no regulatory requirement governing the length of their duty times or required rest periods. Therefore in a similar manner our Technicians are also subject to the effect of fatigue.

In order to meet the needs of our corporate mission, Technicians are periodically scheduled to be "on call" at night during the hours that our aircraft are operating. Most times these are the same Technicians who have already worked a full shift during the day. Compounding this situation is the fact that a call may include the necessity that the Technician travel to an outstation in order to fix a broken aircraft. All of this pushes their period of wakefulness into an extended region. Many times these same individuals are then scheduled to work their normal shift the next day.

The solution here is not so clear-cut especially regarding employees who are paid by the hour. For some individuals the desire to make more money (or not lose any) may tempt them to extend themselves into an undesirable position where fatigue may begin to affect their decision-making and job performance. A mandatory period of compensatory rest after an extended duty period may be one solution.

**Please complete the short Quiz on the next page. Be sure to print your name in the space provided and return it to Nik Pagerly in RDG no later than:**

**July 6, 2007**