CANADIAN FORCES
FLIGHT SAFETY INVESTIGATION REPORT (FSIR)

FINAL REPORT

FILE NUMBER: 1010-124A419
DATE OF REPORT: 3 AUGUST 2001

AIRCRAFT TYPE: CH 124A Sea King
DATE/TIME: 1310Z, 4 MAY 99
LOCATION: SHEARWATER, NS
CATEGORY: "C" CATEGORY GROUND ACCIDENT

SYNOPSIS

Aircraft CH12419 had undergone maintenance actions to repair an unserviceable number-2 engine Gas Generator (Ng) tachometer and required a 'leak check' on the number-2 engine so that the aircraft could be declared 'serviceable'. The pilot started the number-2 engine without the rotor and pylon in the flight 'spread' position and without the number one engine running. The number-2 engine 'emergency start' switch was employed to override the safety interlocks of the start system. After the number-2 engine was started, the pilot advanced the throttle and the main rotor head shifted, causing C category damage to the aircraft. During this event, the pilot observed a loud noise and the number-2 engine was shutdown. No personnel were injured in this occurrence.

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1. FACTUAL INFORMATION

1.1 History of the Flight

The aircraft had undergone maintenance for Ng fluctuations on the number-2 engine and required an engine run and leak check to be declared 'serviceable'. The pilot briefed the three-person start crew that he would start the number-2 engine with the aircraft rotor system in the folded position. The pilot was the only person in the aircraft at the time of the start. In order to accomplish the briefed start procedure, the pilot used the emergency start switch to override the safety interlocks designed to ensure that the number-2 engine cannot be started without the rotor system spread and number-1 engine running with the utility hydraulic system pressurized. Rotor brake pressure was about 470 PSI before the start was attempted. With the number-2 engine started, the pilot observed the Ng was fluctuating and two members of the start crew joined the pilot in the aircraft. After the pilot selected the fuel boost pumps on and off several times, he elected to advance the number-2 Speed Selector Level (SSL) to try to stabilize the fluctuations. When the SSL was advanced to between 85-95 % Ng, the rotor head shifted causing damage to the folded rotor blades, the tail rotor and the pylon structure. During this action, a loud bang was noted in the cockpit and the pilot secured the number-2 engine.

1.2 Injuries to Personnel

Nil

1.3 Damage to Aircraft

All five main rotor blades and two of the tail rotor blades sustained damage and required replacement. As well, the tail rotor gust lock, hub assembly, a pitch link and a pitch change beam sustained sufficient damage to require replacement. A 'Rotary Wing Sudden Stoppage Inspection' was utilised to determine the damage incurred on the Main Gearbox (MGB), the Main Rotor Head (MRH), Tail Rotor Drive shafts and the MGB oil cooler and blower assemblies; all were subsequently replaced by the contractor. Third line contractor repaired structural damage to the fuselage, tail cone and the strake.

This occurrence was rated as a C category ground accident.

1.4 Collateral Damage

There was no collateral damage resulting from this occurrence.

1.5 Personnel Information

	Pilot
Rank	Capt.
Currency/Category as of	MHC 23 Feb 99
Medical Category valid	Yes
Total flying time	859
Flying hours on type	585
Flying hours last 30 days	29
Duty time last 24 hrs	8.0

1.6 Aircraft Information

The aircraft had undergone malfunction rectification for a fluctuating Ng. The Ng tachometer for the number-2 engine had been replaced and the aircraft required a 'leak check' on that engine to confirm serviceability. There were no anomalies noted with the aircraft's record set and the aircraft was maintained in accordance with applicable orders.

1.7 Meteorological Information

Not applicable.

1.8 Aid to Navigation

Not applicable.

1.9 Communications

Not applicable.

1.10 Aerodrome Information

Not applicable.

1.11 Flight Recorders

The Sea King is not equipped with any onboard flight safety recording devices; its absence did not bear upon the investigation.

1.12 Wreckage and Impact Information

All of the aircraft components remained attached to the aircraft. The blade boot for the number three blade was torn open at the stitching and the securing rope failed.

1.13 Medical

Standard toxicological samples were taken, albeit approximately four hours after the accident. The samples were routed to Armed Forces Institute of Pathology (AFIP) in Washington for analysis. Analysis by the medical staff of the investigation team concluded that there were no medical factors contributing to the occurrence.

1.14 Fire, Explosives Devices, and Munitions

Not applicable.

1.15 Survival Aspects

The force levels involved in this occurrence did not pose a threat to the pilot or ground personnel.

1.16 Test and Research Activities

Nil

1.17 Organizational and Management Information

1.17.1 Upgrade Process

The Maritime Helicopter (MH) community requires its pilots to submit to an upgrade process as they gain operational experience. Upon joining the squadron and successfully completing a Unit Check-Out (UCO), a new pilot is granted the MH Co-pilot (MHCP) category. He must then undergo 18-24 months of on the job training (OJT) and a series of examinations and check rides before being granted the category of MH Captain (MHC).

1.17.2 MHC Required Knowledge

An MHC is expected to have a detailed knowledge of the aircraft systems and be capable of handling the aircraft in all regimes of flight. At this level of experience, an MHC may sign-out an aircraft as aircraft captain. Normally a navigator would act as Crew Commander for missions for which an MHC acts as aircraft captain, but the MHC remains responsible for the safety of the aircraft and crew.

The occurrence pilot successfully completed his MHC upgrade in February 1999.

1.17.3 Self-Authorization

The occurrence pilot's category was Maritime Helicopter Captain (MHC). According to the occurrence Squadron Standing Orders (SSOs), this category allows personnel to 'self-authorize' for shore-based training missions provided they are listed on the approved daily flying schedule. This ground run was not included on the schedule; nevertheless, the pilot involved in this occurrence authorized the task himself. A later non-scheduled mission was also self-authorized.

1.17.4 Manning Requirements

At the time of the accident, 1 CAD orders required that two appropriately qualified personnel must be in the aircraft for "a number-2 engine and/or head run". There was only one person in the aircraft for this occurrence.

1.18 Additional Information

The Aircraft Operating Instructions (AOI)(C-12-124-A00/MB-000 pg 2-2-19) states in the 'Starting No.2 Engine Prior To No.1 Engine' section - "CAUTION Main rotor blades shall be spread prior to starting No.2 engine".

1.19 Useful or Effective Investigation Techniques

The Flight Safety Investigation team reviewed the pilot’s training records, Unit Aircrew Proficiency Record, Unit Employment Record and the Operational Training Unit records.

2. ANALYSIS

2.1 General

The task of starting an engine to perform a 'leak check' occurs regularly in Sea King squadrons. Any qualified Sea King pilot may occupy the right seat for an engine or head run. 1 CAD orders (at the time of the occurrence) required one of the following to occupy the left seat and read the checklist:

a. An MH Pilot;

b. An untrained pilot;

c. A 514 technician;

d. An AESOP; or,

e. An Air Navigator.

The orders are quite explicit that during a number-2 engine run (main rotor blades not turning) or a head run (main rotor blades are turning), two qualified personnel must be in the cockpit, as described above.

2.2 The Aircraft

2.2.1 Normal Engine Run Procedure

The established procedure for the assigned task of running number-2 engine for a leak check is:

a. Start the number-1 engine in 'accessory drive';

b. Spread the rotor system to the 'flight position';

c. Start the number-2 engine and run it for the required time interval;

d. Shutdown the number-2 engine;

e. Fold the rotor system; and;

f. Shutdown the number-1 engine.

g. The Blade Fold System

The Sea King rotor head is hydraulically folded after flight and held in place by a combination of hydraulic pressure from a blade fold accumulator (keeps the blades in the proper folded position) and rotor brake friction (keeps the head from

turning). With the rotor in the folded position and with the number-2 engine running, the only device stopping the main rotor head from rotating is the rotor brake, which will overcome the power of the number-2 engine at idle. During a normal start sequence the number one engine is operated in 'Accessory Drive', which means that engine power is mechanically locked out of the drive train and only powers the accessory package of generators and hydraulic pumps. Therefore, the number-1 engine can be started and accelerated to the normal operating range without danger of displacing the folded rotor blades. The blades would then be spread prior to starting the number-2 engine.

2.2.2 Safety Interlocks

There is no such drive train lockout system for the number-2 engine. Although the rotor brake is capable of holding the head in a fixed position with the number-2 engine at ground idle, the AOI prohibits starting the number-2 engine with the blades folded because of the possibility of a rotor brake failure (or human error producing the same results). The system is designed with safety interlocks (micro-switches) that do not permit electrical power to the number-2 engine starter unless the blades are spread and the rotor brake pressure is above 300±20 PSI. In order to start the number-2 engine while the blades are folded it is necessary to select the emergency start switch 'ON' and therefore by-pass all of the safety interlocks and route electrical power to the starter motor.

2.2.3 Mechanism Causing Damage

The output of a normal operating Sea King engine is up to 1350 shaft horsepower. When the number-2 engine SSL was advanced from ground idle towards the normal operating range (85-95 % Ng), the engine output exceeded the holding capacity of the rotor brake and the main rotor head began to rotate. The rotation of the main rotor head in the folded position directly caused all of the observed damage.

2.3 The Accident

The pilot briefed the start crew on his intention to start the number-2 engine and then to proceed with the five-minute engine run and subsequent leak check. The members of the start crew were uneasy about this deviation from normal procedure and all three members tried to communicate their unease to the pilot. While a direct statement was not used to voice the concerns of the start crew, they did enquire as to how the pilot intended to override the 'Safety Interlocks' of the blade fold system. The pilot had decided to override the interlocks using the 'Emergency Start' switch that would allow power to the start circuitry regardless of the 'Safety Interlock' status. Analysis of the reported conversation between the pilot and the start crew led the investigation team to believe that the start crew felt that they were being as direct about their concerns as they could, but the pilot interpreted their concerns as a statement of problems which could be

overcome. Furthermore, the use of a switch labelled 'Emergency' to override a 'Safety Interlock' did not cue the pilot to the danger of his proposed procedure.

2.4 The Pilot

The pilot's election to conduct a prohibited procedure without substantial reason and without direct approval of a supervisor, led the investigation team to conduct a review of the members UAPR, UER and Conversion Course Reports and to interview his peers and supervisors concerning his attitude and work habits. It was found that the impression held by the majority of supervisors differed greatly from that of the occurrence pilot's peers. Investigation revealed that there was one recorded written complaint about aggressive behaviour, in-flight arguments and unsafe flight manoeuvres, also a near-miss occurrence attributed to these aggressive behaviours, and multiple statements provided to the investigation team that supported the fact that peers and immediate supervisors were aware of his proclivity towards inappropriate behaviour. No one indicated an unwillingness to fly on his crew, as he was well liked and his flying skills were satisfactory. The investigation team found that no documented corrective action was taken on the individual until after the written complaint was filed, and then action was limited to verbal counselling.

The following events were necessary to the occurrence of this accident:

a. The pilot had to decide not to consult the chain of command (in accordance with SSOs for the authorization of unscheduled missions). This constitutes a practice contrary to the orders;

b. The pilot had to decide to start number-2 engine without first starting the number one engine and spreading the blades, as per the aircraft operating instructions. It is a reasonable conclusion that the act of starting number 2 engine while the blades were folded was a knowing contravention of the orders (AOI) rather than a lack of knowledge;

c. The pilot had to decide to advance the speed lever beyond the normal idle range in an effort to troubleshoot the Gas Turbine (Ng) surges. This increased power output beyond that which the rotor brake could overcome. This constituted an error in judgement, in that the pilot chose a course of action that was inappropriate.

This occurrence was thus apparently a continuation of a trend of departures from procedures and other inappropriate behaviours. Furthermore, the fact that there were no tangible consequences, resulting from any of the pilot’s known aggressive behaviours, seems to have led to a perception, on the part of the pilot and his peers, that he was “invulnerable” and that he could get away with things others could not.

2.5 Active Factors

2.5.1 System Knowledge

The pilot professed to be unaware of the AOI 'Caution' that prohibited the start of the number-2 engine without the rotor in the 'flight' spread position. As an MHC he should have been conversant with his AOI, and a basic knowledge of the blade fold system (as required to attain MHC status) combined with forethought, should have certainly given the pilot some indication of the hazards associated with his course of action. It is clear that the pilot was sufficiently conversant with the blade fold system to know how to disable the safety interlocks, which themselves are specifically designed to prevent this type of occurrence. Presuming the pilot was indeed unaware of the AOI caution; the fact that the checklist procedure was deliberately modified to abbreviate the start is sufficient to conclude that published orders were contravened.

2.5.2 Pilot Judgement

The pilot involved with this occurrence stated he had never before observed the starting of the number-2 engine with the aircraft in the folded position. The only reason for attempting the abbreviated start procedure would be a slight economy of time. The normal procedure would take about 30 minutes and the attempted procedure would take about 15-20 minutes. The investigation team could find no reason for urgency with respect to the scheduled duties of the occurrence pilot or any operational requirement for the aircraft. It is concluded that the pilot demonstrated faulty judgement in choosing to contravene the AOI caution and abbreviate the ground run procedure at significantly increased risk with no concomitant benefit.

2.6 Latent Factors

2.6.1 Cockpit Resource Management (CRM)/ Risk Management (RM)

The start crew had felt uneasy about the proposed procedure briefed by the occurrence pilot. All three members said they had voiced their concerns, but when questioned about their exact conversation, they acknowledged that they may not have clearly stated that the procedure was dangerous or that it could damage the aircraft. They firmly believed that they had stated, as strongly as they could, that they did not agree with the pilot's intention to start the number-2 engine with the aircraft in the folded configuration. This led the investigation team to question why the pilot had not taken the advice from the start crew into consideration or requested more information from more experienced personnel or consulted the AOI.

CRM training is designed to improve crew communications and permit all crewmembers to have input and share their knowledge or concerns. Accident

investigation reports abound with examples where junior crewmembers knew of an existing hazard, but did not clearly communicate the problem because of the hierarchical nature of a military crew or the belief that the senior pilot must know what he is doing. When effectively employed, CRM helps to eliminate the communication barriers within a crew and thereby reduce the number of preventable occurrences.

The pilot had received CRM training during conversion training (1997) and had attended one day of a four-day syllabus immediately prior to the occurrence. Nevertheless, an ambiguous warning is more difficult to interpret than a direct statement and for this reason CRM training advocates stating perceived problems as bluntly as possible. Because the warning from the start crew was not categorical, the pilot did not perceive it or chose not to interpret it as a warning.

Human Performance in Maintenance (HPIM) is a relatively new initiative that has been developed to duplicate the benefits of CRM in the context of maintenance personnel. HPIM was not, (and is still not) a mandated program, and was not in use in this unit at the time of the occurrence. The occurrence start crew indicated that although they believed the planned procedure to be imprudent, they felt that they could not directly challenge the pilot. HPIM and CRM concepts sanction the challenge of authority where safety is involved, so the start crew may have been better placed to prevent the accident with prior HPIM training.

The occurrence pilot was not the only member of the squadron to have received only one session of CRM training since basic pilot training. Other members of the squadron reported receiving similar amounts of CRM training. As with any skill, abilities and proclivity to use them decrease with disuse and therefore lack of recurrent training for the pilot produced less than ideal CRM skills. When combined with a start crew that had not benefited from HPIM training, the likelihood of miscommunication was increased.

2.6.2 Authorization

As previously noted, the occurrence pilot authorized both this and a subsequent non-scheduled mission himself. This is contrary to SSOs where it is stated that an MHC can self-authorize shore-based missions only when they are on the flying schedule. There was no attempt on the part of the occurrence pilot to seek appropriate authorization. Further, no evidence could be found that squadron supervisors required the proper authorization process to be followed, at least not for this pilot. It is therefore concluded that the mission was not properly authorized, that this pilot not seeking appropriate authorization was not an isolated occurrence, and that this requirement was not always being enforced by squadron supervisors.

2.6.3 Knowledge of 1 CAD Orders

Interviews with the supervisory personnel of the squadron revealed that the pilot was expected to conduct the engine run as prescribed in paragraph 2.2.1 above. There was some question at the supervisory level about whether a pilot could conduct the ground run solo, or if in fact, another qualified person was needed. The 1 CAD order, (Vol. 3, Book 4, Chapter 76, paragraph 8 - Number Two Engine and Head Runs) clearly stated, at that time, that for a "number two engine and/or head run" two qualified pilots or an MHC with another suitably qualified person occupying the left seat is required.

Since pilots are routinely tasked to conduct head runs from their OTU training on, this order applies often and should be well known. The fact that it was not well understood signifies a problem; whether this was an attitude at that time toward the incomplete conversion from MAG Orders to 1 CAD orders, or some other cause is not clear. It is clear that there was a lack of knowledge or understanding of that 1 CAD order.

2.6.4 Training and Quality Assurance

The MHC qualification is based upon the Squadron Standards Officer's (and ultimately the Squadron Commanding Officer's) determination that the member has satisfied the MHC qualification criteria. MHC upgrade written and oral examinations and a flying proficiency test are completed once the member receives the recommendation of his Detachment Commander.

Though not stated in the MH CUP or CTS, it is understood that an MHC must have sufficient technical knowledge of the aircraft to accept responsibility for its safe operation, and must have demonstrated sound judgement and good leadership skills. The Commanding Officer must find the individual trustworthy of commanding a multi-million dollar aircraft and safeguarding the lives of his crewmembers.

There is sufficient evidence in the pilot's UAPR to indicate that the system knowledge requirement was adequately satisfied. However, evidence concerning his in-flight behaviour calls his judgement and leadership abilities into question. This situation was either not detected or not acted upon; given discussions with some of the senior supervisors, the former is more likely. There are many potential reasons for this: supervisors could have been overloaded, had insufficient opportunity to perceive the evidence, or not been provided with the skills to detect it; the pilot’s positive characteristics (such as flying skill) could have affected their willingness to believe negative news (the “halo effect”); or it could have been perceived as too difficult a situation to deal with. Whichever it was, clearly an individual’s attitude had gone unchecked until it caused an expensive accident

2.6.5 Organisational Processes and Safety Culture

For some of the reasons already noted, there was a marked dichotomy between the opinion of the occurrence pilot's peers concerning his attitude and capabilities and that of the senior officers on the squadron. Though evidence exists that individuals at all levels were at one time or another made aware of the occurrence pilot's aggressive nature, all seemed willing to accept any perceived shortcoming as something "you just get used to". The investigation team discovered no evidence of a formal investigation leading to effective corrective action.

Human Factors analysis found that an informal, "nice guy" approach was being taken by squadron flying supervisors toward hazard prevention. This approach is not generally successful in modifying behaviour patterns as apparently ingrained as those of the occurrence pilot. It is believed that the pilot was given no incentive to modify his behaviour, and indeed possible that his behaviour was not seen as excessively inappropriate. The fact that one supervisor defended a non-standard start procedure as a positive indication of an ability to improvise which is required during abnormal situations at sea, further supports this conclusion. Furthermore, as stated in section 2.4, the pilot's behaviour may be indicative of a perceived invulnerability.

Whether through misperception, lack of knowledge, skills or tools, or an unwillingness to "rock the boat", supervisors did not deal with a situation which should have been perceivable. Reports of undisciplined in-flight behaviour were not completely addressed. The conclusion that this contributed to the outcome of this accident is inescapable.

2.7 Other Safety Concerns

N/A

3. CONCLUSIONS

3.1 Findings

3.1.1 The occurrence pilot was current and qualified as an MHC to conduct the mission.

3.1.2 The occurrence pilot was medically fit at the time of the accident.

3.1.3 There were no anomalies in the aircraft maintenance record set prior to the occurrence.

3.1.4 Weather was not a factor in this occurrence.

3.1.5 At the time of the occurrence, 1 CAD Orders required 2 qualified personnel to conduct a number two engine run.

3.1.6 The occurrence mission was not published on the authorized squadron daily flying program and the occurrence pilot authorized the mission himself contrary to the policy stated in the SSOs.

3.1.7 The occurrence pilot and squadron supervisors evidenced a lack of familiarity with 1 CAD Orders concerning ground runs and the SSO on MHS self-authorization.

3.1.8 The mission was not properly authorized in accordance with SSOs.

3.1.9 The occurrence pilot conducted the mission single pilot, contrary to 1 CAD orders.

3.1.10 The occurrence pilot started the number-2 engine while the blades were folded, contrary to the caution published in the AOI, and contrary to the procedure indicated in the checklist.

3.1.11 The occurrence pilot demonstrated poor judgement by deciding to advance the throttle past ground idle to troubleshoot a surging malfunction, causing the rotor head to shift and inflicting C category damage.

3.1.12 Supervisors failed to correct the occurrence pilot's flying deficiencies despite some evidence to indicate the requirement.

3.1.13 The occurrence pilot last completed CRM training during conversion training at the Operational Training Unit in 1997 and lacking currency, did not

alter the unsafe behaviour patterns, or make use of the warning cues that were presented to him.

3.1.14 HPIM was not mandated, taught or practised at the occurrence squadron.

3.1.15 The occurrence ground crew personnel were not confident in their ability to directly challenge the pilot's intended course of action, and therefore used non-assertive words and demeanour to convey their concerns.

3.1.16 The prevailing safety culture on the squadron was less stringent than the situation dictated and insufficient to appropriately intervene in a timely fashion.

3.2 Cause(s)

3.2.1 Contrary to the AOI, and good judgement, the occurrence pilot intentionally started the number-2 engine while the main rotor blades were folded.

3.2.2 The occurrence pilot advanced the number 2 engine throttle to a point where power overcame the capacity of the rotor brake, causing the head to shift and resulting in C category damage.

3.3 Contributing Factor(s)

3.3.1 Squadron supervisors placed insufficient faith in, or failed to react to, evidence of known aggressive flying behaviour.

3.3.2 The tasking authority failed to ensure that the mission was properly authorized and conducted in accordance with all orders and safe flying practices.

3.3.3 The occurrence pilot did not seek proper mission authorization as required by SSOs.

3.3.4 Lack of current CRM/HPIM training removed a critical safety barrier and therefore allowed the pilot to proceed with a planned unsafe act.

4. SAFETY MEASURES

4.1 Safety Measures Taken

4.1.1 The Commanding Officer of 423 (MH) Sqn and the Wing Commander 12 Wing were debriefed on the preliminary findings of the investigation by the FSI team on 14 May 99.

4.1.2 1 CAD Orders were amended to permit single pilot head runs by MHC / MHCC qualified pilots.

4.2 Further Safety Measures Recommended

4.2.1 It is recommended that all flying supervisors be provided with the knowledge, skills and tools to detect undisciplined tendencies and behaviour, and to address it promptly, firmly, fairly and formally through a recognized process.

4.2.2 It is recommended that all flying squadrons be required to consider the utility, for that unit, of instituting a mandatory formal procedure to document and investigate complaints of inappropriate flying procedures and take action to correct identified deficiencies.

4.2.3 It is recommended that 1 CAD:

a. Update the CRM package to increase communication effectiveness for the entire aviation team (aircrew and ground crew), to include recurrent training requirements;

b. Consider using this accident as an example of communication failure in CRM training, and

c. Investigate the requirement to mandate HPIM training.

4.3 Other Safety Concerns

Nil.

4.4 DFS Remarks

The major lesson to be learned from this accident is the insidiousness of inappropriate, undisciplined behaviour. Cues that it is developing can be missed or discounted because they develop slowly - each development inoculates us against the next instalment - or because they are obscured by other factors or issues: the “halo effect”, workload, or missing supervisory skills to name a few. Most of us are familiar with the USAF CZAR 52 case study, and few of us believe

it could happen here, but nobody believed it could happen there either. We can't point to many results as spectacular (I purposely said many rather than any), but after 9 months on this job, I have already seen several instances where we were heading in a similar direction; this is one of them. The point is not that it happened in this squadron, but that it can happen to any of us, and easily before we recognize it. This accident demonstrates the requirement for training for flying supervisors to give them the skills, knowledge and tools required to recognize the signals, and to take firm, fair, positive and prompt action in the face of undisciplined behaviour.

The fact that one supervisor defended a non-standard start procedure as a positive indication of an improvisational attitude is of some concern to me. There is a huge difference between improvising to meet urgent operational imperatives while considering all the risks and dealing with them in a disciplined way, and the situation presented herein. Discerning that type of difference is an important skill for our leaders.

This accident further underscores the requirement for every member of the air force team to become a systems expert on his or her aircraft type, and to exercise discipline in the use of that expertise. Each of us must strive to achieve our own level of excellence, and then expect and ensure the same from our subordinates and peers. This is the way to operational capability, not just safety.

R.E.K. Harder
Colonel
DFS

Annex A: Photographs

Figure 1 - 419 Drive Train Damage

Figure 2 - 419 Tail Rotor - Rear View