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## Mondial Top Scan

NAFLIC has been informed of a dangerous occurrence involving a Mondial Top Scan which took place on a device operating in the UK and a modification which was subsequently issued by the manufacturer.

There is now a modification in place from Mondial and controllers of such devices are recommended to carry this out and to contact the manufacturer for further information.

The following information has been provided by the IB involved.

### Brief description of malfunction

The malfunction occurred when the operator pushed the “boom up” button and instead of booming up, the main arm spun in a clockwise direction and the gondola arm drove into the floor.

An attentive ride operator noticed the unexpected rotation and immediately pressed the E-stop button of the device which halted motion of the arm and no-one was harmed in the incident. The malfunction was reported to the HSE under the RIDDOR scheme.

The initiating cause of this incident has been identified to be the failure of the main arm brake solenoid valve resulting in a voltage drop to the 24V control system from 24V to 10-13 V. The voltage drop caused several hydraulic valves to fail to switch correctly, resulting in hydraulic oil being directed to rotate the arm instead of raise the boom. This unexpected torque in combination with release of the arm parking brake allowed the arm to be driven into the floor.

This failure was not detected by the control system as no monitoring of valve position or detection of unexpected rotation is present in the original system design.

### Factors contributing to malfunction

Following investigation it was identified that several aspects of the device design could contribute to a malfunction of this type:

- When power is removed from the arm parking brake solenoid the brake is released.
- Not all directional control valves are configured in a ‘fail safe’ way, i.e. under loss of control voltage, some valves provide hydraulic flow to actuators of the device.
- Unexpected rotation of the arm is not detected by the control system of the device.
- The control system does not monitor the position of valves of the device.
- The safety relay for the device does not automatically stop the device in the event of a control system voltage drop.
- The impedance of the control circuit combined with the extra low voltage power supply was not sufficient to cause the circuit breaker to trip fast enough to prevent harm occurring due to the arm rotation.
- The device relies upon a battery back-up system which requires the condition of the battery to be periodically checked.

## Advice for owners and inspectors of Mondial Top Scan devices

The manufacturer of the device (Mondial) has proposed a modification to the control system of the device to address the hazard of unexpected arm movement.

Owners of Mondial Top Scan devices should contact Mondial at the earliest opportunity for advice regarding this hazard.

## Additional measures for owners to mitigate the risks highlighted

Mondial have proposed measures which could reduce the likelihood of a malfunction of this type occurring (these are in addition to the proposed modification):

- The ride only being operated by a competent member of staff who is full aware of the ride history and the actions required to monitor the ride operation and prevent an incident.
- Increasing the load testing of the ride braking system to ensure that it is fully operational and will restrict any unintended movement.
- Recording, monitoring and reporting of any abnormal operations. Review and assessment of any abnormal operations.

From discussion with the HSE the following recommendations have been made regarding measures to mitigate the risk of unexpected arm movement:

- Training of ride staff should re-enforce the need to monitor for unexpected motion whilst the main mast of the device is being raised and lowered (at the start and end of the ride cycles), ensuring a member of staff is paying full attention and within arm's reach of the E-stop during these critical stages of the operating cycle.
- The boarding control for the device should not be used during operation with guests.
- A procedure should be in place to ensure the battery is permanently connected to the charger.
- A daily check of the battery condition should be carried out.
- An indication of low battery voltage should be visible in the operator console.
- A periodic test of the battery on load should be carried out e.g. weekly. This could be:
  - i. With the hydraulic power packs on, switch off the battery charger.
  - ii. Isolate power to the device.
  - iii. Try to push the gondola away from the home position (if safe to do so).
  - iv. Record the battery voltage after 20 minutes and set a limit against which to assess this.

## Advice for owners and inspectors of other devices incorporating control systems

Although the malfunction has occurred on a Top Scan device, some of the potential causes of the malfunction could be present in other ride designs where an electronic/hydraulic control system is present. It is recommended for all ride owners and inspectors to be aware of the following:

- i. Where a single hydraulic power supply is used to power different actuators, failure modes in which fluid is directed to the wrong actuator should be considered.
- ii. Where solenoid valves can direct hydraulic fluid to actuators in the de-energised state (i.e. the de-energisation principle is not fulfilled):
  - Can this result in hazardous movement in the event of a component failure?
  - How is hazardous movement detected?
  - Can hazardous movement be interrupted before harm occurs?

- iii. Where a safety relay is used, unless explicitly stated by the manufacturer, the relay is not guaranteed to detect a voltage drop and initiate a safe state, even if the voltage falls far below the tolerance of the device.
- iv. Where battery-back up systems are relied upon for safety functions (e.g. braking, control system back-up, emergency recovery) the following should be periodically checked:
  - The battery is connected to a charger which maintains its voltage when the main power to the device is switched off.
  - The battery voltage (when disconnected from the charger) is adequate for the operation.
  - The ability of batteries to maintain their voltage under load when disconnected from the charger should be periodically tested e.g. by an on-load test which is significantly longer than the time required for the safety function to be carried out.

*Some of the information contained within is that of the manufacturer and not NAFLIC. When following the advice from the manufacturer, you are reminded of your duties and responsibilities under HSG175 regarding modifications.*

Committee Members: Mr. D Dadswell (Chairman), Mr. A Mellor (Secretary), Mr. P Smith, Mr. J Green, Mr. D Cox, Mr. M Thirkettle, Mr. I Davies, Mr. J Shilling & Mr. D Inman

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