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(54) Title: CONVEYOR BELT RIP PANELS AND BELT RIP MONITORING

(57) Abstract: A conveyor belt rip monitoring system is disclosed. The system includes at least one rip panel having a conductive loop positioned in or on a conveyor belt so that the loop extends substantially across the width of the belt. The conductive loops may be formed from metallic or non-metallic materials. An RFID chip is electrically coupled to the loop and provides a signal to an RFID interrogation unit positioned on the conveyor structure indicative of the health of the conductive loop. If a break is sensed in the loop, the RFID chip sends an appropriate signal to the interrogation unit which passes the information to a processing system. A unique resistor or diode may be included in the circuit between the chip(s) and the legs of the loop so that the interrogation unit can distinguish one leg or loop from another. If the break in the loop is determined to be due to a rip in the conveyor belt, the processing system alerts a user of the rip condition via an attached display device. For large scale rips the system may automatically stop the conveyor belt. Various embodiments of rip detection panels are also disclosed.
CONVEYOR BELT RIP PANELS AND BELT RIP MONITORING

REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of International application No, PCT/GB2006/003190 filed August 29, 2006, and U.S. Provisional Serial Nos. 61/098,389, 61/098,461 and 61/098,378, filed September 19, 2008, each of which is hereby incorporated by reference.

FIELD OF THE INVENTION

[0002] The invention relates to systems for monitoring industrial conveyor belt systems, and more particularly to an improved rip panel for use in detecting longitudinal rips in conveyor belts and a system that employs such a panel.

BACKGROUND

[0003] Conveyor belts and conveyor systems are widely used in the transport of a variety of materials and products. Conveyor belts may be used in light or heavy materials transport. For heavy materials transport often the belts have reinforcing cords of steel or other material embedded in the belt to provide additional tensile strength. For lighter material transport such reinforcing cords may be formed of lighter weight non-metallic fibers or cords. In some lightweight applications no reinforcing cords are used.

[0004] Rip damage can arise in any of these belts during operation. For example, such a rip can occur when the belt is penetrated by an object which has become jammed so that it does not move with the belt. As the belt is driven forcibly against an object that penetrates the belt, a longitudinal rip may develop rapidly along an extended portion of
the belt. Such a condition can render the belt unsuitable for the continued transport of material so that the belt must be taken out of service, in extreme cases, the whole belt may require replacement. In other cases, the damaged section must be repaired. As will be appreciated, this can result in financial losses due to the cost of belt repair or replacement and the inconvenience of suspending manufacturing or other operations which rely on continued operation of the conveyor.

[0005] Various attempts have been made to provide a rip detection system which can promptly stop operation of a conveyor belt if a rip has occurred. One such prior assembly is shown diagrammatically in FIG. 2, which is a top plan view on a conveyer system belt 2 and hopper 10. Transmitters and receivers 5, 7 are mounted above the belt 2 near loading or discharge sections where most belt rips occur. Antennae 3 are embedded intermittently throughout the conveyor belt. The control box 9 receives power from power source box 11 and sends a signal through the transmitters to each antenna as it passes by the transmitter. The signal passes through the antenna 3 back to the receiver and the control box. The control box receives the signal and evaluates the message. If the signal doesn't reach the receiver, it means a belt tear has interrupted current flow through the antenna 3. Lack of a transmitted signal indicates that damage has occurred to the belt, and the power to the belt shut off by the control accordingly.

[0006] There are shortcomings, however, to such prior rip detection systems. Only one type of information is provided—signal or lack of a signal. Gradual decrease in signal strength, which could provide useful information as to belt wear, for example, is not detectable. For prior systems to operate effectively the transmitters and receivers must be positioned a precise distance from the antennae and control box during belt operation; and in loading and discharge sections of the conveyor belt, material may easily collide with the nearby transmitter(s)/receiver(s) causing them to become misaligned with the antennae or to cease functioning altogether. Additionally, the transmitters, receivers, and their corresponding electrical connections can fail or become undependable over time. Belt down time frequently occurs as a result.
[0007] There is, therefore, a need for an improved rip detection system that is cost effective, reliable, and which does not itself impact the function of the belt.

SUMMARY OF THE INVENTION

[0008] The disadvantages heretofore associated with existing rip detection systems are overcome by the disclosed design for a conveyor belt rip monitoring system. Thus, a conveyor belt rip panel monitoring system is disclosed, which includes: (1) a conductive loop, (2) a Radio Frequency Identification (RFID) chip electrically connected to the conductive loop, (3) an RFID interrogator positioned to receive information about the conductive loop from the RFID chip, (4) a processing system associated with the RFID interrogator for receiving a signal from the interrogator and processing the signal to obtain a measure of the integrity of the conductive loop, and (5) a user interface for providing an indication of the integrity of the conductive loop to a user.

[0009] The RFID interrogation unit can read and write to one RFID chip or a plurality of chips located on or in the belt. The RFID chip may also provide to the interrogator information relating to a rip panel associated with the belt. The rip panel information may include one or more of the members of the group consisting of: rip panel model information, rip panel brand/OEM information, rip panel age information and rip panel repair history.

[0010] In another aspect of the invention, the conductive loop and the RFID chip are connected to a rip detection panel, and the panel is positioned between layers of the conveyor belt. The belt may include a plurality of rip panels, and the panels may be positioned at approximately 200 foot intervals along the length of the belt.

[0011] A resistor or diode may be electrically connected to the conductive loop and the RFID chip. The conductive loop may be formed from a non-metallic conductive material. The non-metallic conductive loop may include a plurality of legs electrically coupled with the RFID chip. A plurality of loops may be formed from a plurality of legs, and one leg of each loop may be electrically connected to the RFID chip by a resistor or
The processing system may be a programmable logic controller (PLC) rack system, and the interrogation unit may be connected to the processing system via an Ethernet switch. The system may be operably connected to a data communications network, which may comprise, for example, a facility-wide monitoring system, an Intranet, a virtual private network or the Internet.

In still another aspect of the invention, the RFID chip also provides to the interrogator information relating to the model, brand/OEM, age and repair history of the rip panel associated with the belt.

In yet another aspect of the invention, the system includes at least one camera for transmitting visual information regarding the conveyor belt to a user.

A belt control system may also be operably connected to the monitoring system for directly or indirectly changing the operation of the conveyor belt in response to the signal(s) from the interrogator.

One object of the invention is to provide an improved conveyor belt rip panel and belt rip monitoring system, which is capable of promptly ceasing operation of a conveyor belt if a rip has occurred. Another object of the invention is to provide an improved rip detection system that is cost effective, reliable, and that does not itself impact the function of the belt. Related objects and advantages of the invention will be apparent from the following description.

**BRIEF DESCRIPTION OF THE DRAWINGS**

The details of the invention, both as to its structure and operation, may be obtained by a review of the accompanying drawings, in which like reference numerals refer to like parts, and in which:
[0018] FIG 1 is a side partial diagrammatic view of an exemplary conveyor belt rip monitoring system;

[0019] FIG. 2 is a top plan view of a prior art rip detection system;

[0020] FIG. 3 is a cutaway perspective view of a conveyor belt showing an embodiment of the RFID chip and conductive loop of the invention embedded in a layer of the belt;

[0021] FIG. 4 is a section view, taken along line 4-4 of FIG. 3, showing an embodiment of a rip panel with an associated RFID chip of the invention;

[0022] FIG. 5 is a plan view of an exemplary rip panel for use with the conveyor system of FIG. 1;

[0023] FIG. 5A is an enlarged plan view of the RFID chip of FIG. 5;

[0024] FIG. 6 is a plan view of another exemplary rip panel for use with the conveyor system of FIG. 1;

[0025] FIG. 7 is a plan view of a further exemplary rip panel for use with the conveyor system of FIG. 1; and

[0026] FIG. 8 is a section view, taken along line 8-8 of FIG. 5A, showing an embodiment of the RFID chip with material forming the belt extending through a bore formed in the chip.

DETAILED DESCRIPTION

[0027] An improved system is disclosed for monitoring conveyor belts to detect rips that can occur in operation. Specifically, the disclosed system will detect early stages of longitudinal rips in conveyor belts so that the rips can be closely monitored and/or the belt can be stopped before catastrophic failure occurs.
Referring to FIG. 1, an exemplary conveyor belt rip monitoring system 1 is shown. A conveyor system 2 may have a reinforced conveyor belt 4 which extends around two end pulleys 6, 8. One of the two pulleys may be powered by a motor to drive the belt. The belt 4 may pass under a loading hopper 10 such that material from the hopper 10 is transported by the load-carrying working surface 12 of the belt 2 in a direction to the left in FIG. 1. At one end pulley 6 the material falls into a second, collection hopper 14.

At a position downstream of the loading hopper 10 and facing the underside 16 of the belt 2 an RFID interrogation unit 18 is provided. In one embodiment, the interrogation may comprise an antenna with a reader/writer. It will be appreciated that although it is illustrated as being under the belt, one or more interrogation units 18 may be provided in any appropriate location with respect to the belt, as long as it can read one or more RFID chips located on or within the belt. The system may have more than one RFID interrogation unit 18. Where multiple units 18 are provided, they may be positioned at particular locations of interest, such as at the beginning of the belt return section, or near the end pulley 6 at a position downstream of the unloading hopper 14. As will be described in greater detail later, the interrogation unit 18 may be connected to a processing system 19 to enable processing of information received from the interrogation unit. In one embodiment, the RFID interrogation unit 18 can read and write to one or more RFID chips located in or on the belt 2. For purposes of this description the aforementioned chip(s) may be an RFED chip electronically connected to a conductive loop as described below, or the chip(s) may include an RFID chip located near or otherwise associated with a corresponding rip panel.

Referring now to FIGS. 3 and 4, exemplary conveyor belt 2 may have upper and lower rubber cover layers 20, 22 between which are sandwiched one or more longitudinal reinforcement layers 24 of reinforcing cords embedded in rubber. In some embodiments these reinforcing cords are made from steel, while in other embodiments they may be non-metallic materials. Yet other embodiments incorporate a fabric layer or no reinforcing layer at all. For belts utilizing one or more reinforcing layers 24, a rip
detection panel 26 may be positioned between one of the cover layers 20, 22 and the reinforcement layer 24. The rip detection panel 26 may be assembled as a pre-formed strip in which all the elements of the panel are embedded in rubber or other flexible material. The strip may then be vulcanized into the belt during manufacture to ensure long term belt and panel stability.

[0031] It will be appreciated that a conveyor belt 2 may be provided with any appropriate number of such rip panels at longitudinally spaced intervals along the belt 2 in order to ensure that a rip in a section of belt is detected before it becomes too large. In one embodiment, rip panels will be positioned at approximately 200 foot intervals along the belt.

[0032] Referring now to FIGS. 3-5A, the illustrated panel 26 comprises a conductive loop 28 having an RFID chip 30 and a resistor or diode 32 coupled thereto. "Panel" for purposes of this description means any material to which the loop 28, chip 30, and resistor/diode 32 may be connected, including the conveyor belt layer or layers, and which can be made to travel around end pulleys 6, 8 in a manner commensurate with the functions of the invention herein described. The RFID chip 30 may include at least one bore 31, preferably more than one, formed there through so that material 33 during the aforementioned vulcanization or other manufacturing process may extend through the bore(s) 31 and firmly secure the chip 30 to the belt or the panel accordingly, as shown for example in FIG. 8. The resistor or diode 32 may be used for identification of open circuit, short circuit, or healthy panel conditions depending upon the current sensed by the RFID chip 30 as it passes the interrogation unit 18. The interrogation unit 18 positioned on the conveyor structure will switch on the RFID chip 30 as it passes the unit.

[0033] The RFID chip 30, in turn, will identify a measured current/resistance and will transmit representative information back to the interrogation unit for analysis. This information may be used for sensing a variety of conditions, including a rip condition. For example, the RFID chip 30 may send a 1-bit to the interrogation unit to represent a good condition, and a 0-bit to represent a damage (rip) condition.
Referring again to FIG. 1, the interrogation unit 18 may be connected to a processing system 19, which in one embodiment is a programmable logic controller (PLC) rack system. For simplicity of connection, the interrogation unit 18 may be connected to the processing system 19 via an Ethernet switch 34. The processing system 19 may have a processor 36 capable of executing instructions for analyzing the received signals and for assessing a condition of one or more rip panels 26 based on the received signals. Thus, depending upon the magnitude of the current/resistance sensed by the RFID chip 30 associated with a particular rip panel 26, the processing system 19 can determine the condition of that panel. The system may determine that a rip has been detected, the severity of the rip, whether the panel itself has degraded over time, and so on. The executable instructions run by the processor 36 may be customized by the user to analyze the signals and to trigger alarms (for cases in which slight rips have been detected), or to stop the belt automatically in cases where large rips are detected.

In use of the disclosed system, a baseline reading from each RFID chip 30 of each rip panel 26 may be obtained during a first cycle of the belt around the pulleys 6, 8. During subsequent cycles the reading from each RFID chip 30 may be compared with the original reading, and the occurrence of any significant changes noted to determine whether the change is indicative of a rip, or other condition in the belt.

For system embodiments in which multiple panels 26 are provided along the length of the conveyor belt 2, each panel 26 may have a resistor/diode 32 with a unique resistance to provide further level of panel identification. Alternatively, or in addition, the RFID chip 30 may itself provide automatic identification of the individual panels 26. Examples of such identification information include the model, brand/original equipment manufacturer (OEM), age, repair history, if any, and the like.

The conductive loop 28 may comprise any of a variety of conductive materials, such as metal and non-metallic conductors. Examples of suitable metal conductors include copper and platinum. Non-limiting examples of a suitable non-metallic conductor may include graphite, or an elastomeric conductive material such as that manufactured by NanoSonic, Inc., of Blacksburg, Virginia, sold under the trademark.
"METALRUBBER." In other embodiments, the conductive loop can be in wire or ribbon form, as desired, which can be of suitably low resistivity such that it can be operated in conjunction with the RFID chip.

[0038] One substantial benefit of using a non-metallic conducting material to form the conductive loop 28 is that it is expected to add little to the overall lateral stiffness of the conveyor belt 2. Conventional rip panels that utilize a plurality of laterally-oriented conductive metal wires can add substantial lateral stiffness to the conveyor belt. This increased lateral stiffness may make it more difficult to "trough" the belt (i.e., where the angled rollers of the conveyor structure force the belt to conform to a V or U-shape in order to confine and carry the load material) in operation. In addition, forced troughing of the laterally stiff rip panels can cause premature failure of the rip panel due to the fatigue of repeated bending of the metal wires or cords.

[0039] Referring now to FIG. 6, an embodiment of a non-metallic rip panel 126 is disclosed. Similar to the previously described rip panel 26, rip panel 126 comprises a plurality of conductive legs 128 that are electrically coupled with an RFID chip 130. The RFID chip 130 of this embodiment may have any or all of the characteristics of the RFED chip 30 described in relation to FIG. 5. Thus, the RFED chip 130 may be configured to provide information to the interrogation unit 18 relating to the integrity of one or more of the conductive legs 128 (e.g., whether a partial or full rip has occurred in one or both), and may also provide detailed information about the panel such as model, brand, age, repair history (if any), and the like. Thus, as the RFID chip 130 passes the interrogation unit 18 it will be switched on. It will send a current through the legs 128 and will send a digital bit to the interrogation unit indicating whether the circuit is closed (good) or open (bad). It may also provide an indication if one or more legs are only partially ripped. Another RFED chip, like the one shown in association with the previously described rip panel 26, may provide information about the belt.

[0040] FIG. 7 shows an alternative embodiment of a non-metallic rip panel 226 incorporating a plurality of loops formed from a plurality of conductive legs 228 electrically coupled to an RFED chip 230. The RFED chip 230 of this embodiment may
have any or all of the characteristics of the RFID chips 30, 130 described in relation to FIGS. 5 and 6. Thus, the RFID chip 230 may be configured to provide information to the interrogation unit 18 relating to the integrity of one or more of the conductive legs 228 (e.g., whether a partial or full rip has occurred in one or both), and may also provide detailed information about the panel such as model, brand, age, repair history (if any), and the like. An additional chip (not shown) may be associated with the panel 226 like that shown in FIG. 5 with respect to the panel 26 of that embodiment.

[0041] In this embodiment, a single RFID chip 230 may be used to monitor multiple loops, simultaneously, and to provide the interrogation unit with information regarding the ongoing integrity of the individual legs 228 of the rip panel 226. This arrangement may provide more detailed information about a rip in the conveyor belt 2 as compared to previous embodiments due to its greater longitudinal extent (owing to the multiple-loop configuration). Thus, it may be possible to more accurately estimate the extent or length of a longitudinal rip in the belt by knowing exactly how many legs 228 have been broken by the rip. As can be seen, one leg of each loop is connected to the RFID chip 230 by a resistor (or diode) 232 having a unique resistance so that the RFID can immediately determine which leg has been breached by the rip.

[0042] Thus, as the RFID 230 passes the interrogation unit 18 it will be switched on. It will send a current through the legs 228 and will send a digital bit to the interrogation unit indicating whether the circuit is healthy or open/damaged. For the instant embodiment, the RFID may send a signal representing 1-1-1-1 to show a typical (i.e., good) condition. Alternatively, the RFID chip 230 may send a signal representing 0-1-1-1 to show a damage condition in the first leg. This damage condition may then be interpreted as a rip in the belt. Damage to more than one leg would be indicative of a longer rip. Unlike prior systems, therefore, the disclosed arrangement may also provide an indication if one or more legs are only partially ripped.

[0043] In addition to the features described above, the system 1 may also comprise a camera 38 (FIG. 1) for transmitting visual information regarding a top surface 12 of the belt cover to enable the user to correlate information provided by the system
with a visual indication of the belt at a particular location. While the illustrated embodiment shows the camera 38 positioned beneath the belt, it will be appreciated that the camera could be positioned in any desired location to obtain images of the belt top or bottom surfaces. In addition, multiple cameras 38 may also be provided, including cameras having high definition capabilities. The cameras may be adjustable to pan a desired location, and they may also have zoom functionality to focus on a particular area of interest. The signal from the camera 38 can be routed to the processing system 19 through the Ethernet switch 34. The camera 38 may be controlled (e.g., to take continuous video images, or to take a snapshot at a targeted location) by the processing system 19. In one embodiment, the processing system may signal the camera to automatically take a picture based on a triggering event (e.g., where a rip condition is sensed).

[0044] The processing system 19 may also provide a connection to a belt control system 40 to control the belt 2 as desired. Thus, the processing system 19 may be used to instruct the belt control system 40 to slow the belt speed and/or to stop a targeted portion of the belt at a specific location within the mine so that the belt can be inspected and/or repaired. Alternatively, if the processing system 19 predicts an imminent failure condition in the belt, the processing system 19 may instruct the belt control system 40 to immediately stop the belt 2 regardless of its position.

[0045] The system 1 may further comprise user/operator display 42 for providing information regarding the status of the rip panels 26 in the system. Any or all of the information in this display may be viewed locally, or it may be transmitted to remote users via an appropriate data communications network such as a company's intranet, virtual private network (VPN), the Internet or the like to enable global viewing and control of the system 1. The information can also be e-mailed to one or more individuals (including photographs) so that a remote determination can be made regarding the damage.

[0046] It will be understood that the description and drawings presented herein represent an embodiment of the invention, and are therefore merely representative of the
subject matter that is broadly contemplated by the invention. It will be further understood that the scope of the present invention encompasses other embodiments that may become obvious to those skilled in the art, and that the scope of the invention is accordingly limited by nothing other than the appended claims.
WHAT IS CLAIMED IS

1. A conveyor belt rip monitoring system, comprising:
   a conductive loop;
   an RFID chip electrically connected to said conductive loop;
   an RFID interrogator positioned to receive information about said conductive loop from said RFID chip;
   a processing system associated with said RFID interrogator for receiving a signal from the interrogator and processing said signal to obtain a measure of the integrity of said conductive loop; and
   a user interface for providing an indication of said integrity of said conductive loop to a user.

2. A conveyor belt rip monitoring system according to claim 1, wherein the RFID interrogation unit can read and write to one RFID chip or a plurality of chips located on or in the belt.

3. A conveyor belt rip monitoring system according to claim 1, wherein said conductive loop and said RFID chip are connected to a rip detection panel, said panel positioned between layers of a conveyor belt.

4. A conveyor belt rip monitoring system according to claim 3, wherein said belt comprises a plurality of rip panels, said panels being positioned at approximately 200 foot intervals along said belt.

5. A conveyor belt rip monitoring system according to claim 1, wherein a resistor or diode is electrically connected to said conductive loop and said RFID chip.

6. A conveyor belt rip monitoring system according to claim 3, wherein a resistor or diode is electrically connected to said conductive loop and said RFID chip.
7. A conveyor belt rip monitoring system according to claim 1, wherein said RFID chip further comprises at least one bore formed there through, material forming said belt or said panel extending through the bore such that the chip is firmly held, respectfully, to the belt or the panel.

8. A conveyor belt rip monitoring system according to claim 1, wherein said processing system is a programmable logic controller (PLC) rack system, the interrogation unit being connected to said processing system via an Ethernet switch.

9. A conveyor belt rip monitoring system according to claim 1, wherein the processing system further comprises a processor for executing instructions for analyzing signals received from said RFID interrogator and for assessing a condition of at least one rip panel or said conductive loop.

10. A conveyor belt rip monitoring system according to claim 1, wherein said conductive loop is formed from a non-metallic conductive material.

11. A conveyor belt rip monitoring system according to claim 1, wherein the RFID chip also provides to the interrogator information relating to a rip panel associated with said belt, the rip panel information comprising one or more of the members of the group consisting of: panel model information, panel brand/OEM information, panel age information, and panel repair history.

12. A conveyor belt rip monitoring system according to claim 6, wherein the RFID chip also provides to the interrogator information relating to a rip panel associated with said belt, the rip panel information comprising one or more of the members of the group consisting of: panel model information, panel brand/OEM information, panel age information, and panel repair history.

13. A rip monitoring system according to claim 6, wherein a user display is connected to the system for providing information about the status of the rip panel.
14. A rip monitoring system according to claim 10, wherein said non-metallic conductive loop comprises a plurality of legs electrically coupled with the RFID chip.

15. A rip monitoring system according to claim 14, further comprising a plurality of loops formed from a plurality of legs.

16. A rip monitoring system according to claim 15, wherein one leg of each loop is electrically connected to the RFID chip by a resistor or diode having a different resistance so that the interrogator may distinguish each of the loops from another.

17. A rip monitoring system according to claim 1, wherein said system further comprises at least one camera for transmitting visual information regarding the conveyor belt to a user.

18. A rip monitoring system according to claim 1, wherein a belt control system is operably connected to said monitoring system for directly or indirectly changing the operation of the conveyor belt in response to said signal.

19. A rip monitoring system according to claim 1, wherein said system is operably connected to a data communications network, said network comprising one or more members of the group consisting of; a facility-wide monitoring system, an Intranet, a virtual private network and the Internet.

20. A conveyor belt rip detection panel comprising:
   at least one panel;
   a conductive loop; and
   an RFID chip electrically connected to said conductive loop, wherein said loop and said chip are connected to said at least one panel.
21. A rip detection panel according to claim 20, wherein said conductive loop is integrally formed with said panel.

22. A rip detection panel according to claim 20, wherein a resistor or diode is electrically connected to said conductive loop and said RFID chip.

23. A rip detection panel according to claim 20, wherein said RFID chip further comprises at least one bore formed there through, material forming said panel extending through the bore such that the chip is firmly held to the panel.

24. A rip detection panel according to claim 20, wherein said conductive loop is formed from a non-metallic conductive material.

25. A rip detection panel according to claim 21, wherein said conductive loop is formed from a non-metallic conductive material.

26. A rip detection panel according to claim 24, wherein said non-metallic conductive loop comprises a plurality of legs electrically coupled with the RFID chip.

27. A rip detection panel according to claim 26, further comprising a plurality of loops formed from a plurality of legs.

28. A rip detection panel according to claim 27, wherein one leg of each loop is electrically connected to the RFID chip by a resistor or diode, each of the resistors or diodes having a different resistance so that the interrogator may distinguish each loop from another.
A CLASSIFICATION OF SUBJECT MATTER
IPC(8) - B65G 43/06 (2009.01)
USPC - 198/810 02
According to International Patent Classification (IPC) or to both national classification and IPC

B FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - B65G 43/06 (2009.01)
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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
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C DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
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