

NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

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**Attachment 9 –Hydraulic Check Valve and Hydraulic Case Drain Filter
Materials Analysis Report**

POWERPLANTS

DCA18LA163

A330 MSN 578 DAL fire event - hydraulic check valve Technical Report

REFERENCE	LR29RP2111103
A/C APPLICABILITY	A330
ATA APPLICABILITY	29

SUMMARY:

On April 18, 2018 the yellow hydraulic system was lost in the incident flight of A330 MSN 578, despite fire isolation being activated. The capturing of the failure history and subsequent investigations led to the hypothesis that contaminants may be present in the hydraulic check valve (S/N: 7443), which from now on is designated as check valve in this report. Based on this hypothesis AIRBUS integrated lab was requested to contribute to the failure analysis. This report comprises the instrumental analysis and the examination results thereof.

The check valve was found functioning in laboratory tests using fresh hydraulic fluid both at DAL and Airbus prior to the investigations at AIRBUS integrated lab.

Both microscopy examination and computer tomography reveal the presence of particles attached to the inside wall of the check valve. Chemical analysis using energy dispersive x-ray spectroscopy analysis infer that the particles consist of Al and corrosion resistant steel.

Furthermore, a new hydraulic filter was examined. The filter is of the same type, which was installed upstream to the hydraulic check valve at the time of incident. In the filter three metallic layers made of corrosion resistant steel are identified. Hence, the metallic filter layers could be a source for the particles found inside the yellow case drain valve. However, comparing the mesh size of the finest metallic filter layer with the particle size found inside the hydraulic check valve leads to the conclusion that these type of metallic particles cannot have passed through an intact and operational filter of this type.

In addition to the hydraulic filter a new flexible hydraulic hose of the same type, which was installed upstream to the hydraulic check valve at the time of incident was investigated. Chemical analysis shows that the flexible hose is comprised of three different Fe-Cr-Ni containing components. The sealing within the flexible hose is enabled through an inner non-metallic liner. Hence, even though the flexible hose contains materials, which are chemically similar to the Fe-Cr-Ni particles identified in the yellow case drain valve, in case of thermal degradation most probably the sealing function fails before metallic particles are released from the hose.

Furthermore, neither in the hydraulic filter nor in the flexible hose a potential source for the Al containing particles found inside the check valve is identified.

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1 SCOPE

On April 18, 2018 the yellow hydraulic system was lost in the incident flight of A330 MSN 578, despite fire isolation being activated. The capturing of the failure history and subsequent investigations led to the hypothesis that contaminants may be present in the hydraulic check valve (S/N:7443). Based on this hypothesis AIRBUS integrated lab was requested to contribute to the failure analysis. This report comprises the instrumental analysis and the investigation results thereof.

2 FACTUAL INFORMATION

Table 1: Factual Information Data

Aircraft Data			
MSN:	578	Operator:	DAL
A/C Type:	LR	A/C Flight Cycles:	8317
Registration:	N806NW	A/C Flight Hours:	63750
Part Data			
ATA chapter:	29		
Part Designation:	Hydraulic check valve		
S/N:	7443		

2.1 PART HISTORY

Object of the investigation is a hydraulic check valve (S/N: 7443) which was removed from A330 MSN578 after being involved in the engine fire event of April 18, 2018. The information of the author is that the valve passed functional tests both at DAL and Airbus laboratories subsequent to the fire event. In the functional tests the valve was tested with fresh hydraulic fluid.

3 LABORATORY EXAMINATION

The check valve was investigated using light microscopy, electron microscopy and computer tomography. Furthermore, a new hydraulic filter (PN 7554849) and a new hydraulic flexible hose (BN 9774285) were investigated by light microscopy. This type of hydraulic filter and flexible hose were installed upstream of the hydraulic check valve. The hydraulic filter and the hose were investigated to better understand the constitution of the parts and to be able to evaluate these parts as a potential source of contaminants themselves.

3.1 Incoming Visual Inspection

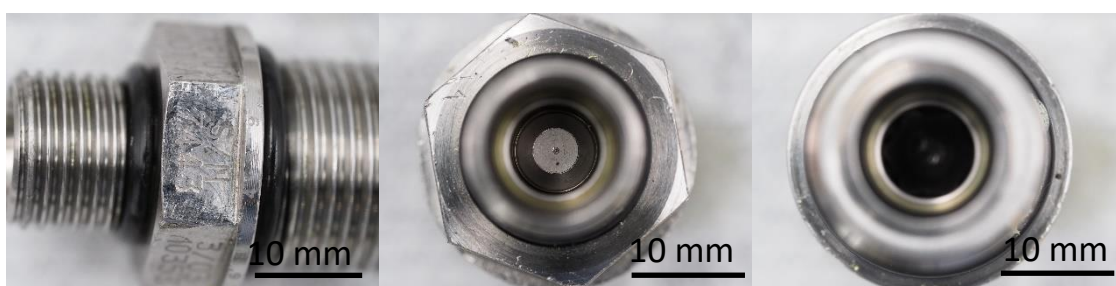


Figure 1 shows the hydraulic check valve (S/N: 7443) at incoming visual inspection

At incoming visual inspection the check valve shows scratches and mechanical wear on the outside surface as seen in Figure 1.

3.2 Examination of the hydraulic check valve

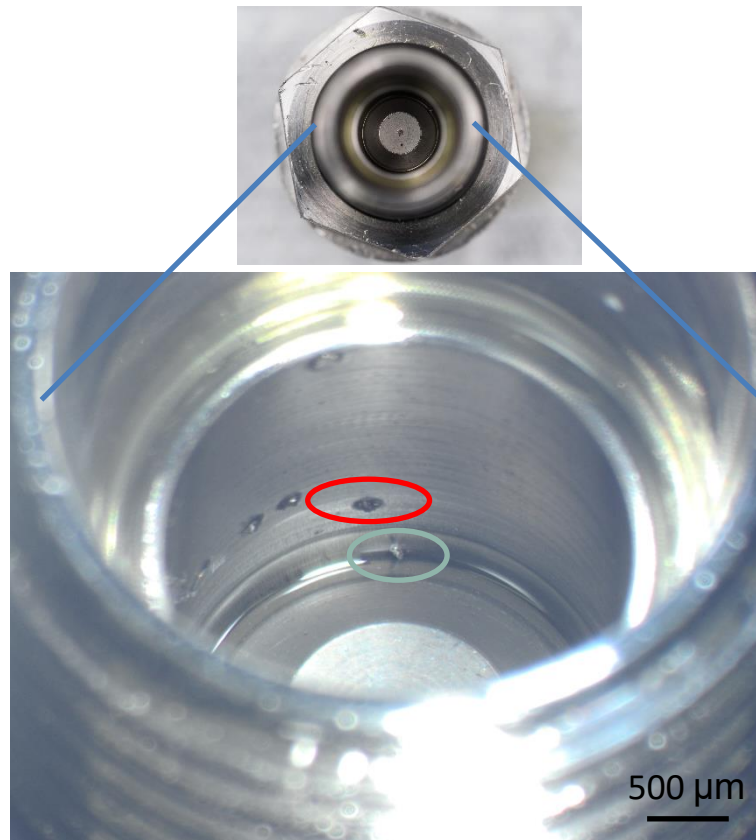


Figure 2 shows the inside walls of the hydraulic check valve (S/N: 7443) in the vicinity of the closing head

Figure 2 reveals the presence of particles attached to the inside walls of the check valve. On the image several of such particles are identified. Two of them are highlighted with green and red circles.

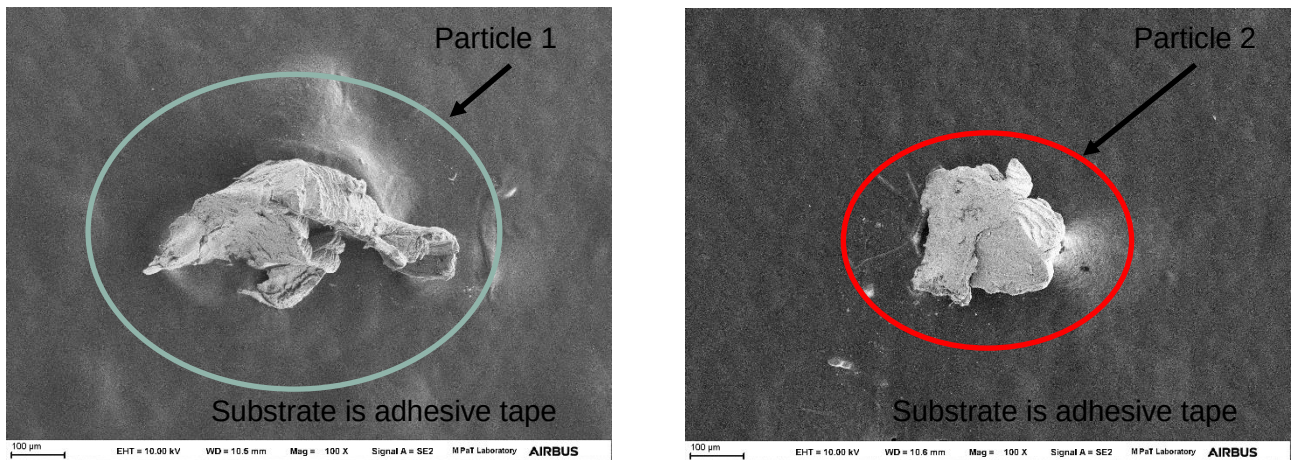


Figure 3 shows electron microscopy images of the particles transferred from the inside surface of the hydraulic check valve (S/N: 7443)

Figure 3 shows the particles transferred from the inside surface of the check valve. The substrate is adhesive tape. The maximum extension of the particles are about 480 and 200 µm, respectively.

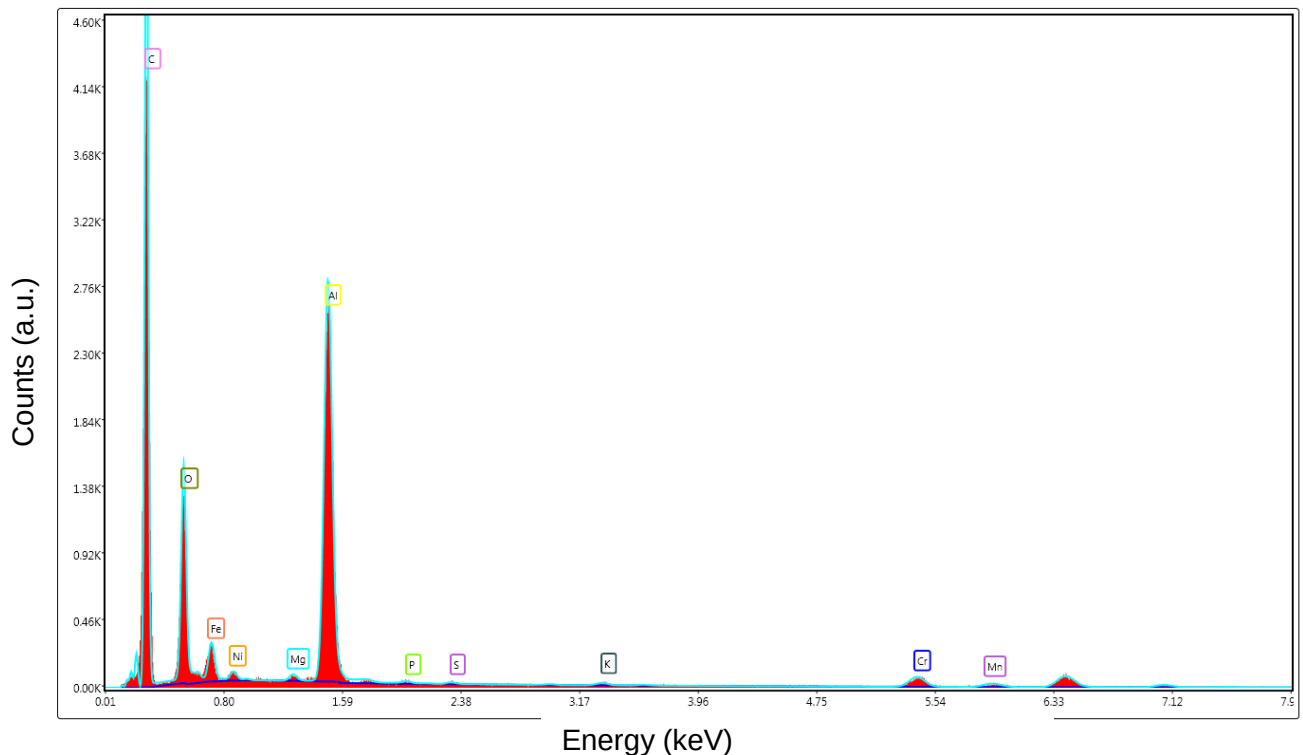


Figure 4 shows the energy dispersive x-ray spectroscopy analysis of particle 1

Figure 4 shows the energy dispersive x-ray spectroscopy analysis of particle 1 shown in Figure 3. The spectrum reveals the presence of mainly Al, C and O. Based on the analysis of the spectrum it is inferred that the presence of C and O is mainly due to residues on the surface of the particle and the particle is mainly constituted by Al.

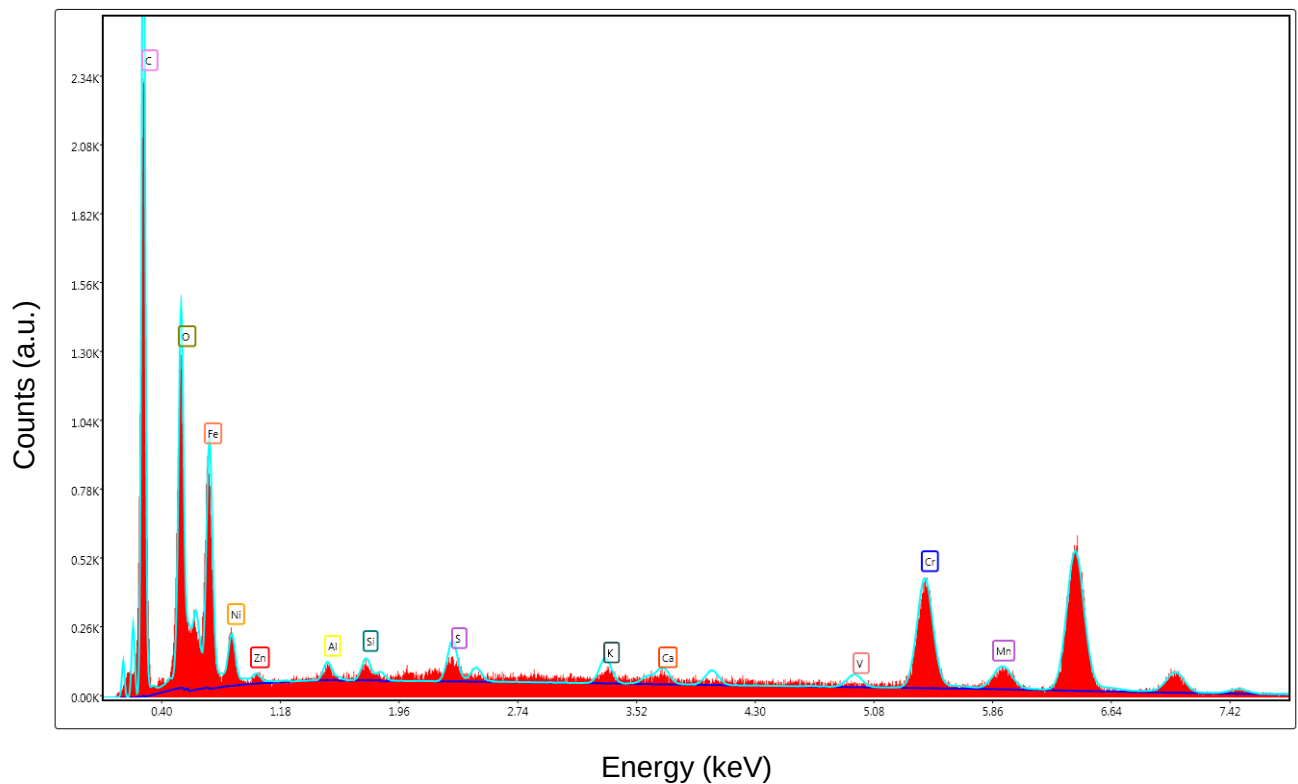


Figure 5 shows the energy dispersive x-ray spectroscopy analysis of particle 2

Figure 5 shows the energy dispersive x-ray spectroscopy analysis of particle 2 shown in Figure 3. The spectrum reveals the presence of mainly C, O and Fe. Furthermore, Cr and Ni are detected. Based on the analysis of the spectrum it is inferred that the presence of C and O is mainly due to residues on the surface of the particle and that the particle is mainly constituted by corrosion resistant steel.

3.3 Computer tomography analysis of the hydraulic check valve

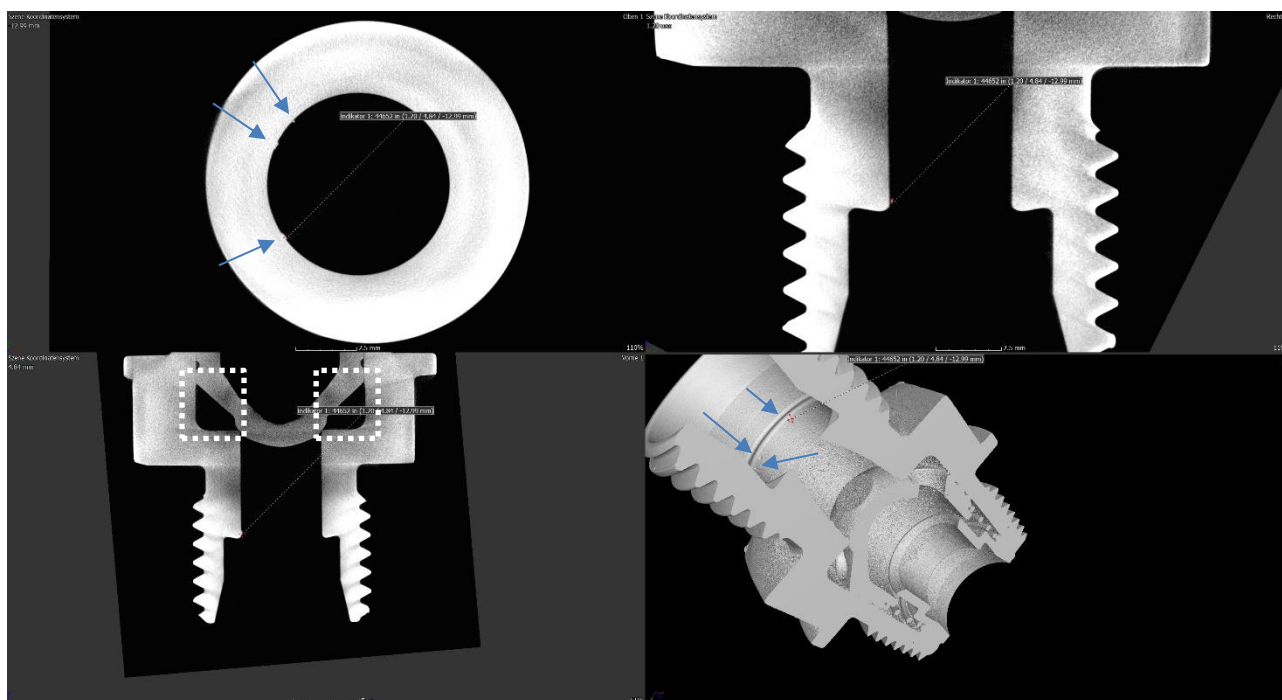


Figure 6 shows computer tomography images of the hydraulic check valve

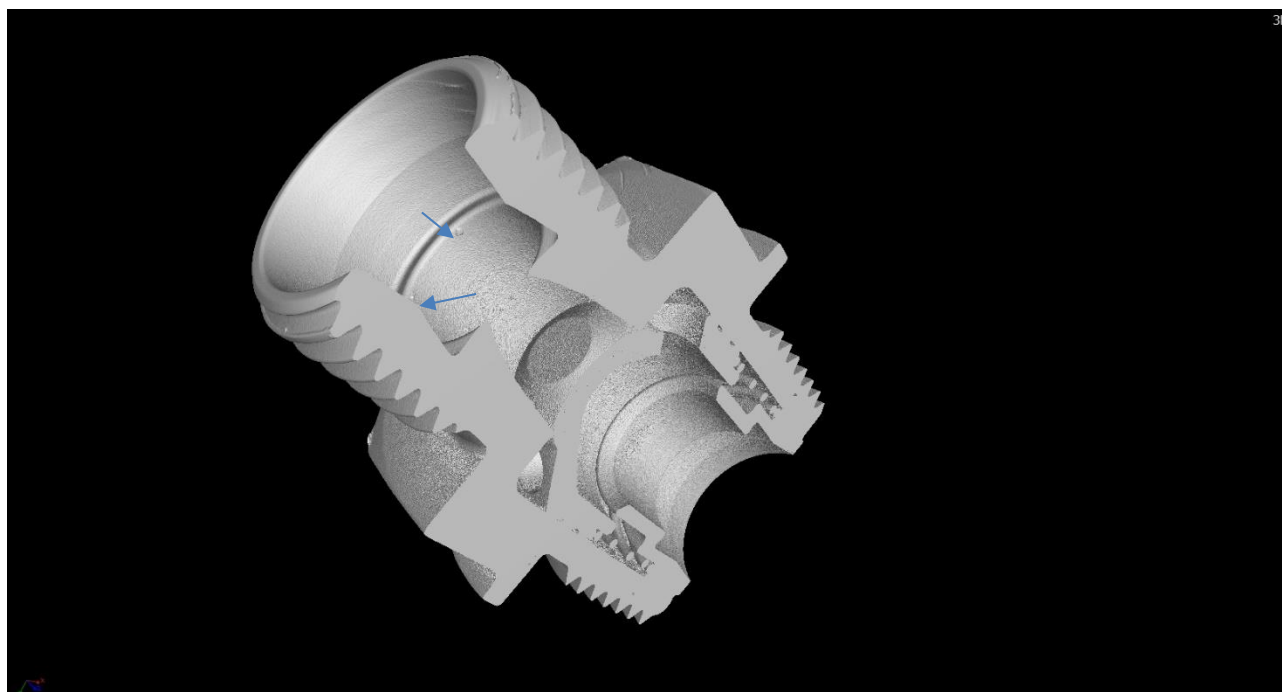


Figure 7 shows a computer tomography image of the hydraulic check valve

The computer tomography images of Figure 6 and Figure 7 show cut planes of the check valve. The computer tomography analysis reveals the presence of particles attached to the inside wall of the

hydraulic check valve. The depicted cut planes are chosen to display the particles identified. In Figure 6 and Figure 7 the identified particles are highlighted with blue arrows. Hence, the computer tomography analysis is in line with the microscopy analysis presented in section 3.2. No particles could be identified in the area behind the sealing edge of the pop-in, highlighted by dashed boxes in Figure 6. Hence, the computer tomography analysis reveals the presence of particles on the inner walls of the check valve upstream of the pop-in sealing edge. However, no particles are identified behind the sealing edge.

3.4 Examination of a new hydraulic filter

A new hydraulic filter was examined. The filter is of the same type, which was installed upstream to the hydraulic check valve at the time of incident. The hydraulic filter was investigated to better understand the constitution of the filter and to be able to evaluate the filter as a potential source of contaminants itself. The filter was cut into 4 pieces as indicated by the red lines in Figure 8 for further analysis. The blue arrows indicate the flow direction of the hydraulic fluid in operation. The hydraulic fluid flows from the hydraulic pump through the outside surface of the filter and exits the filter towards the check valve to the right. Further analysis can be seen in Figure 9.

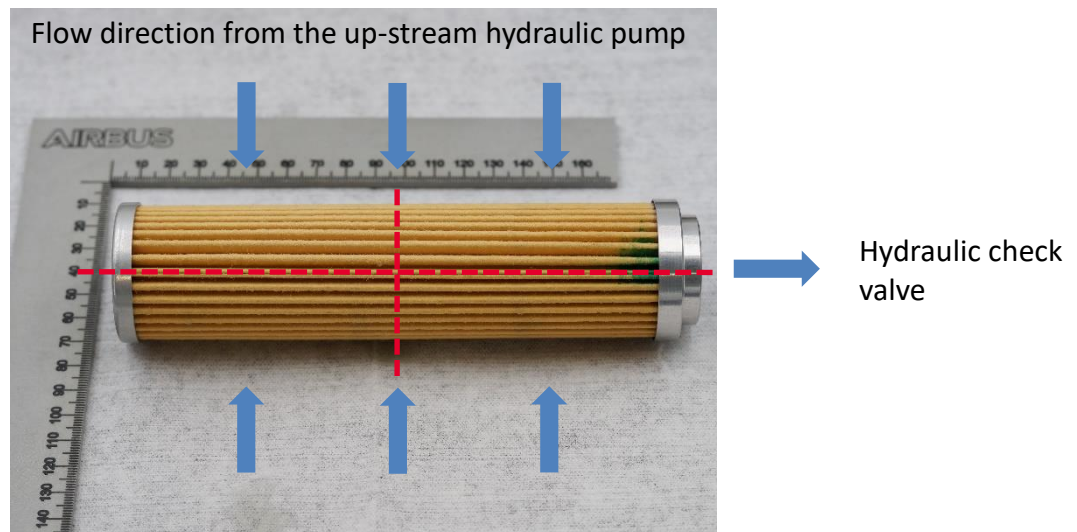


Figure 8 shows the hydraulic filter with the part number 7554849

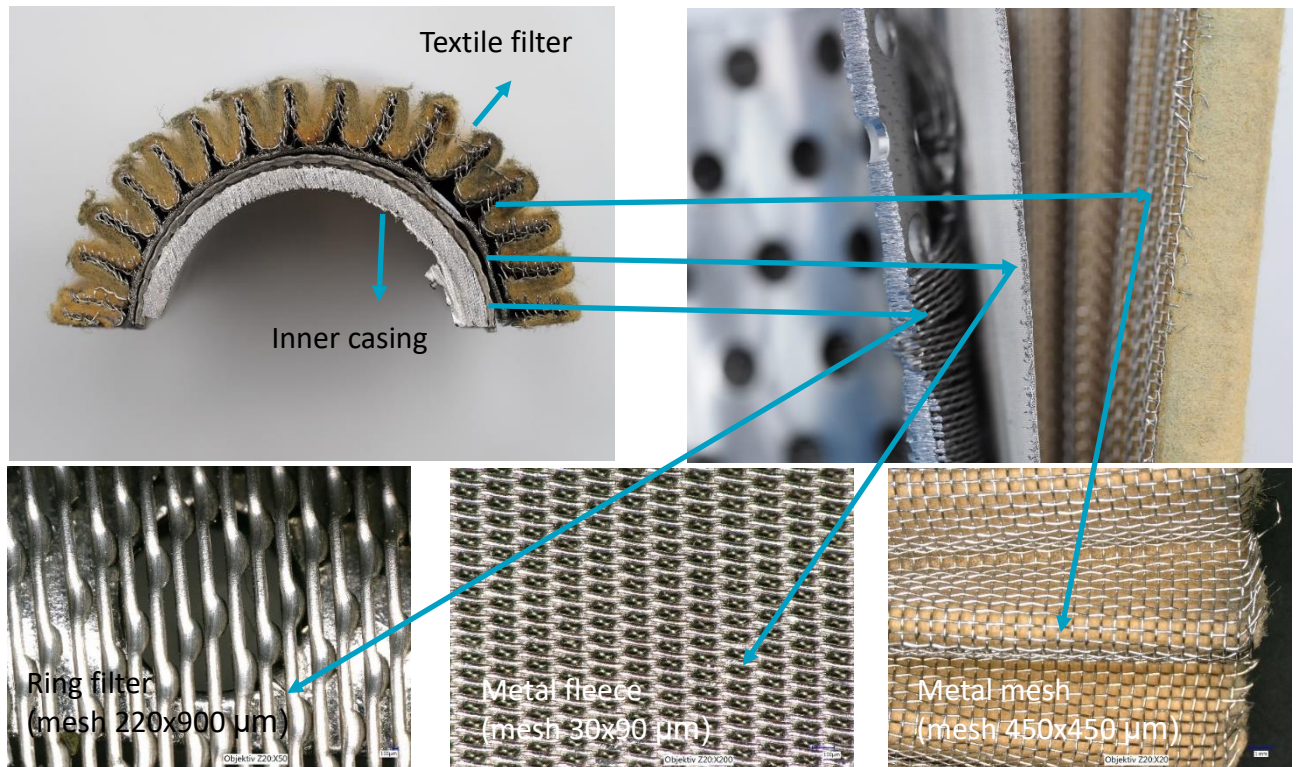


Figure 9 shows a cross-section of the hydraulic filter and microscopic images of the individual layers

In the top left image in Figure 9 the cross section of the hydraulic filter is shown. Five layers are identified in the macroscopic cross-section, which are from the inside towards the outside an inner casing, a ring filter, a metal fleece, a metal mesh and a textile filter. The image on the top right shows a side view into the opened layer structure. Microscopic images of the ring filter, metal fleece and metal mesh are shown below. The individual mesh sizes are 220x900 µm, 30x90 µm and 450x450 µm for the ring filter, metal fleece and metal mesh, respectively. Comparing the mesh size of the metal fleece with the size of the particles found inside the check valve it can be concluded that these type of metallic particles cannot have passed through an intact and operational filter of this type.

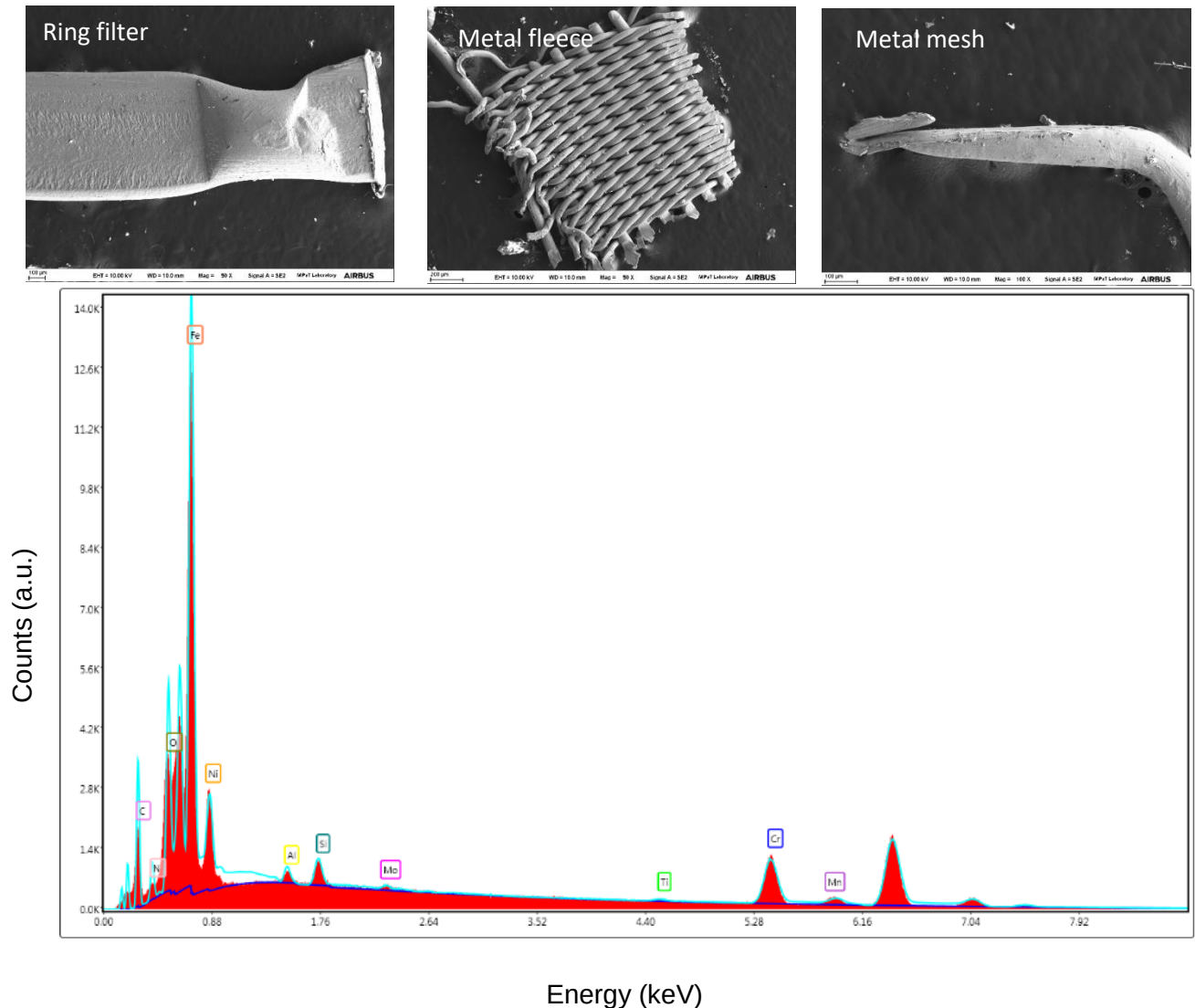


Figure 10 shows electron microscopy images of cut outs of the ring filter, metal fleece and metal mesh. Furthermore, the energy dispersive x-ray spectroscopy analysis of the different filter layers is shown.

The top three images of Figure 10 show electron microscopy images of the ring filter, metal fleece and metal mesh. For the ring filter and metal mesh individual wires were cut out for this analysis. The lower graph shows the energy dispersive x-ray spectroscopy analysis of these three filter layers. The presence of Fe-Cr-Ni infers that all three filter layers are made of corrosion resistant steels. Hence, from the energy dispersive x-ray analysis, it can be inferred that one of the particles found inside the hydraulic check valve (S/N: 7443) and the filter layers are comprised of corrosion resistant steel. Hence, the metallic filter layers could be a source for the Fe-Cr-Ni containing particles found inside the yellow case drain valve.

3.5 Examination of a new hydraulic flexible hose

A new hydraulic flexible hose was examined. The hose is of the same type, which was installed upstream to the hydraulic check valve at the time of incident. The hose was investigated to better understand its constitution and to be able to evaluate it as a potential source of contaminants itself. Figure 11 shows the new flexible hose as received. The flexible hose is about 1 m long and comprised of metallic connectors on either-side and an outer sleeve. The two cut-outs indicated in



Figure 11 – visual inspection of a new hydraulic flexible hose.

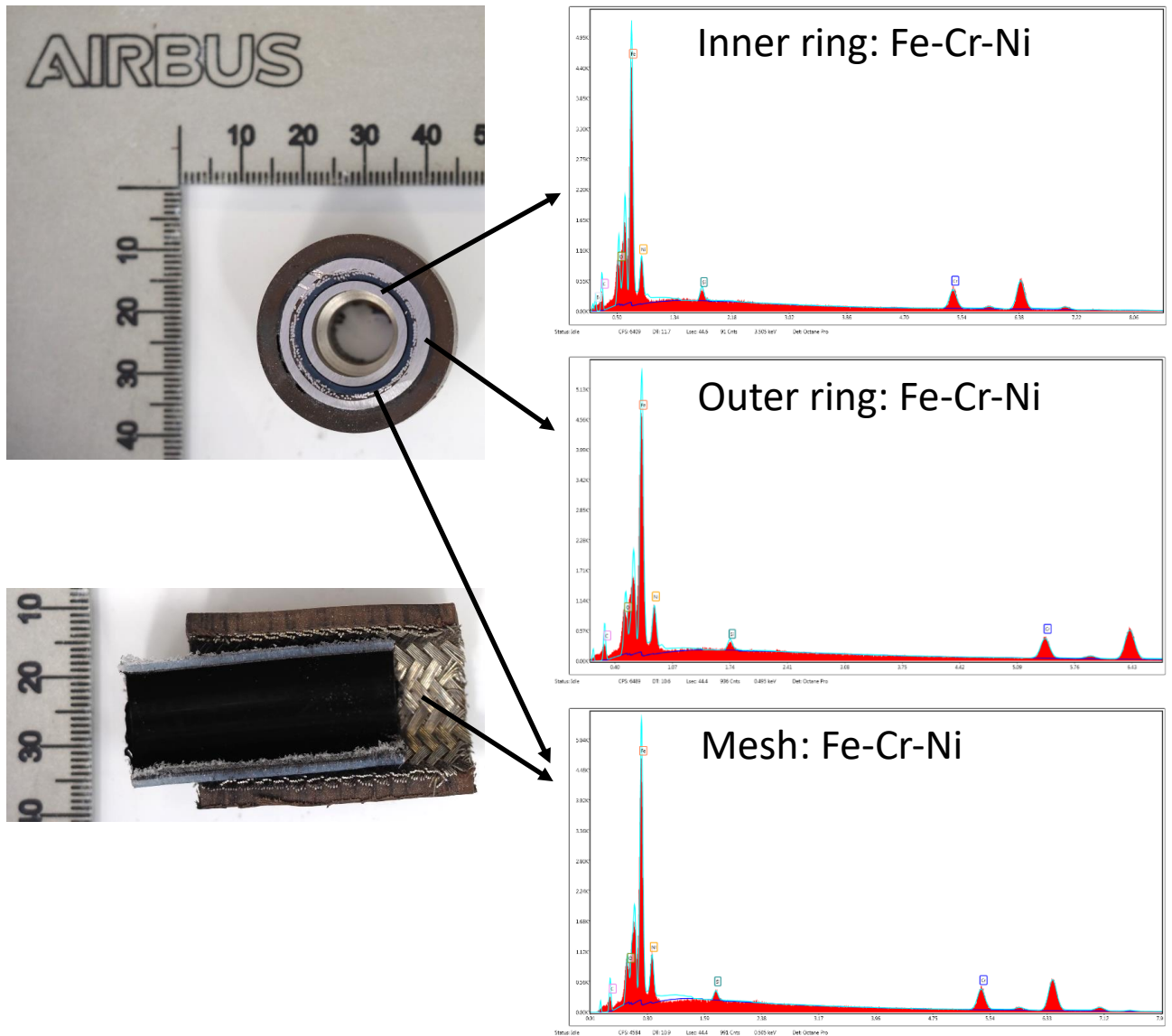


Figure 12 shows cross-sections of the flexible hose cut-outs. Furthermore, the energy dispersive x-ray spectroscopy analysis of the different metallic layers are shown.

From the cross-sectional analysis shown in Figure 12 it is learned that the flexible hose is comprised of an inner liner, a metal mesh and an outer sleeve. In addition, the connector is comprised of two metallic rings. Chemical analysis shows that the inner ring, the outer ring and the mesh of the flexible hose contain Fe-Cr-Ni. Hence, these layers are made out of corrosion resistant steel. The sealing within the flexible hose is enabled through the inner non-metallic liner. Hence, even though the flexible hose contains materials, which are chemically similar to the Fe-Cr-Ni particles identified in the yellow case drain valve, in case of thermal degradation most probably the sealing function fails before metallic parts are released from the hose.

4 SUMMARY

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Furthermore, neither in the hydraulic filter nor in the flexible hose a potential source for the Al containing particles found inside the check valve is identified.

5 APPLIED EQUIPMENT, TERMS AND DEFINITIONS

For the performed investigation, the below mentioned terms and equipment were applied.

Table 2: List of Terms and Equipment

SCANNING ELECTRON MICROSCOPE (SEM) – Zeiss – “Gemini Supra 35VP”
ENERGY DISPERSIVE X-RAY (EDX) – EDAX/Ametek – Octane Pro
COMPUTER TOMOGRAPHY – GE – “PHOENIX V TOME X M 300/180”
DIGITAL MICROSCOPE – Keyence – “VHX”
DOCUMENTATION CAMERAS