

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43

EOS/ESD Association, Inc.



Electrostatic Discharge (ESD) In Data Centers Using Conveyors

*EOS/ESD Association, Inc.
218 West Court Street
Rome, NY 13440*

Published October 2025

**CAUTION
NOTICE**

44
45
50
51
52
53
54
55
56
57
58

Electrostatic Discharge Association (ESDA) standards and publications are designed to serve the public interest by eliminating misunderstandings between manufacturers and purchasers, facilitating the interchangeability and improvement of products, and assisting the purchaser in selecting and obtaining the proper product for his particular needs. The existence of such standards and publications shall not in any respect preclude any member or non-member of the Association from manufacturing or selling products not conforming to such standards and publications. Nor shall the fact that a standard or publication that is published by the Association preclude its voluntary use by non-members of the Association, whether the document is to be used either domestically or internationally. Recommended standards and publications are adopted by the ESDA in accordance with the ANSI Patent policy.

Interpretation of ESDA Standards: The interpretation of standards in-so-far as it may relate to a specific product or manufacturer is a proper matter for the individual company concerned and cannot be undertaken by any person acting for the ESDA. The ESDA Standards Chairman may make comments limited to an explanation or clarification of the technical language or provisions in a standard, but not related to its application to specific products and manufacturers. No other person is authorized to comment on behalf of the ESDA on any ESDA Standard.

**DISCLAIMER OF
WARRANTIES**

64

THE CONTENTS OF ESDA'S STANDARDS AND PUBLICATIONS ARE PROVIDED "AS-IS," AND ESDA MAKES NO REPRESENTATIONS OR WARRANTIES, EXPRESSED OR IMPLIED, OF ANY KIND, WITH RESPECT TO SUCH CONTENTS. ESDA DISCLAIMS ALL REPRESENTATIONS AND WARRANTIES, INCLUDING WITHOUT LIMITATION, WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR USE, TITLE, AND NON-INFRINGEMENT.

**DISCLAIMER OF
GUARANTY**

70
71
72
73

ESDA STANDARDS AND PUBLICATIONS ARE CONSIDERED TECHNICALLY SOUND AT THE TIME THEY ARE APPROVED FOR PUBLICATION. THEY ARE NOT A SUBSTITUTE FOR A PRODUCT SELLERS' OR USERS' OWN JUDGEMENT WITH RESPECT TO ANY PARTICULAR PRODUCT DISCUSSED, AND ESDA DOES NOT UNDERTAKE TO GUARANTEE THE PERFORMANCE OF ANY INDIVIDUAL MANUFACTURERS' PRODUCTS BY VIRTUE OF SUCH STANDARDS OR PUBLICATIONS. THUS, ESDA EXPRESSLY DISCLAIMS ANY RESPONSIBILITY FOR DAMAGES ARISING FROM THE USE, APPLICATION, OR RELIANCE BY OTHERS ON THE INFORMATION CONTAINED IN THESE STANDARDS OR PUBLICATIONS.

**LIMITATION ON
ESDA's LIABILITY**

79
80
81
82
83
84

NEITHER ESDA, NOR ITS PRESENT OR FORMER MEMBERS, OFFICERS, EMPLOYEES OR OTHER REPRESENTATIVES WILL BE LIABLE FOR DAMAGES ARISING OUT OF, OR IN CONNECTION WITH, THE USE OR MISUSE OF ESDA STANDARDS OR PUBLICATIONS, EVEN IF ADVISED OF THE POSSIBILITY THEREOF. THIS IS A COMPREHENSIVE LIMITATION OF LIABILITY THAT APPLIES TO ALL DAMAGES OF ANY KIND, INCLUDING, WITHOUT LIMITATION, LOSS OF DATA, INCOME OR PROFIT, LOSS OF OR DAMAGE TO PROPERTY, AND CLAIMS OF THIRD PARTIES.

85
86
87
88
89
90
91
92
93
94
95
96
97
98

Published by:
EOS/ESD Association, Inc.
218 West Court Street
Rome, NY 13440

Copyright © 2025 by EOS/ESD Association, Inc.
All rights reserved

No part of this publication may be reproduced in any form, in an electronic retrieval system or otherwise, without the prior written permission of the publisher.

Printed in the United States of America

TABLE OF CONTENTS

99

100

101

102 **1.0 INTRODUCTION**

103 **2.0 TYPES OF DATA CENTERS**.....

104 2.1 HYPERSCALE DATA CENTERS.....

105 2.2 AUTOMATED DATA CENTERS

106 2.3 TAPE STORAGE DATA CENTERS

107 2.4 HIGH-DENSITY DATA CENTERS.....

108 2.5 CLOUD AND COLOCATION DATA CENTERS.....

109 **3.0 BENEFITS OF USING CONVEYORS IN DATA CENTERS**

110 **4.0 ELECTROSTATIC CONCERNS IN DATA CENTERS AND CONVEYOR SYSTEMS**.....

111 4.1 ESD IN DATA CENTERS

112 4.1.1 *Damage to Sensitive Equipment*.....

113 4.1.2 *Data Corruption and System Disruption*

114 4.1.3 *Downtime and Reliability Risks*.....

115 4.1.4 *Financial and Reputational Costs*

116 4.2 ELECTROSTATIC RISKS FROM CONVEYOR USE.....

117 4.2.1 *Static Generation by Friction (Triboelectric Charging)*.....

118 4.2.2 *Charge Accumulation from Non-Conductive Materials*.....

119 4.2.3 *Electrostatic Attraction (ESA) and Particulate Contamination*

120 4.2.4 *Increased Risk with Speed and Movement*

121 4.2.5 *Sensor and Control System Vulnerability*

122 **5.0 MITIGATION STRATEGIES**

123 5.1 ESD CONTROLS

124 5.2 ESD TRAINING

125 5.3 CONVEYOR DESIGN

126 5.4 ENVIRONMENTAL CONTROLS

127 **6.0 ESD CONTROL PROGRAMS**

128 6.1 ESD CONTROL PROGRAM COMPONENTS.....

129 6.2 EXAMPLES OF DATA CENTERS WITH ESD PROGRAMS

130 6.2.1 *Hyperscale Data Centers*.....

131 6.2.2 *Colocation Providers*.....

132 6.2.3 *Enterprise Data Centers*

133 6.2.4 *Telecommunications Data Centers*.....

134 6.2.5 *Government and Military Data Centers*.....

135 **BEST PRACTICES FOR USING CONVEYORS IN DATA CENTERS**

136 7.1 MATERIAL SELECTION

137 7.2 GROUNDING AND BONDING.....

138	7.3 ENVIRONMENTAL CONTROLS
139	7.4 OPERATIONAL PROCEDURES
140	7.5 MONITORING AND MAINTENANCE
141	8.0 CONCLUSION
142	9.0 RELEVANT INDUSTRY STANDARDS AND CERTIFICATIONS
143	9.1 ANSI/ESD S20.20 AND IEC 61340-5-1.....
144	9.2 ISO 14644-1 AND ISO 14644-2
145	9.3 ESD TR53®

146 Electrostatic Discharge (ESD) in Data Centers Using Conveyors

147

148 1.0 INTRODUCTION

149 Data centers that use conveyors typically fall into several categories, particularly those that require
150 efficient handling and movement of large volumes of equipment or media. By incorporating
151 conveyors into their operations, these types of data centers can achieve higher levels of efficiency,
152 safety, and reliability, which are critical for maintaining seamless service and handling the
153 complexities of modern data center environments. This document describes different types of data
154 centers, the use of conveyors in each, the benefits of using conveyors in data centers, and the ESD
155 risk of conveyors in data centers.

156

157 2.0 TYPES OF DATA CENTERS

158 2.1 Hyperscale Data Centers

159 These are massive data centers operated by large companies such as Amazon Web Services
160 (AWS), Google Cloud, Microsoft Azure, Apple, and Meta. Data centers support vast numbers of
161 servers and storage devices.

162 Conveyors can be used to automate the movement of servers and storage devices within the
163 facility, from receiving and inventory to deployment and maintenance. This helps manage the scale
164 of operations efficiently and reduces manual labor.

165

166 2.2 Automated Data Centers

167 These data centers leverage high levels of automation for equipment handling, often utilizing
168 robotics in conjunction with conveyors.

169 Conveyors are part of the automated systems that handle the physical transportation of hardware
170 components. This can include moving servers to different racks, transporting storage devices, and
171 even integrating with robotic systems for installation and maintenance tasks.

172

173 2.3 Tape Storage Data Centers

174 These facilities specialize in long-term data storage using magnetic tape libraries, which are often
175 used for archiving and backup purposes.

176 Conveyors in tape storage data centers are used to move tape cartridges between storage
177 locations and tape drives for reading and writing data. This automation helps in efficiently managing
178 large volumes of tape media.

179

180 2.4 High-Density Data Centers

181 These data centers focus on maximizing computing power within a limited physical space, often
182 housing high-density racks with significant numbers of servers.

183 Conveyors assist in the efficient movement and deployment of dense server units, as well as in the
184 maintenance and replacement of hardware, reducing the need for manual handling in confined
185 spaces.

186

187 2.5 Cloud and Colocation Data Centers

188 Cloud data centers provide cloud services to customers, while colocation data centers offer space,
189 power, and cooling for customers' hardware.

190 These data centers can use conveyors to streamline the process of bringing in customer
191 equipment, moving it to allocated spaces, and handling large-scale hardware deployments and
192 upgrades.

193 3.0 BENEFITS OF USING CONVEYORS IN DATA CENTERS

- 194 • **Efficiency** - Automates repetitive tasks and reduces the time required for equipment handling.
- 195 • **Safety** - Minimizes the risk of damage to sensitive equipment and reduces physical strain on
196 workers.
- 197 • **Scalability** - Facilitates the management of large-scale operations and high-density
198 deployments.
- 199 • **Cost-Effectiveness** - Reduces labor costs associated with manual handling and increases
200 overall operational efficiency.

201

202 4.0 ELECTROSTATIC CONCERNS IN DATA CENTERS AND CONVEYOR SYSTEMS

203 Data centers are critically focused on mitigating risks associated with electrostatic discharge (ESD)
204 and electrostatic attraction (ESA), particularly when using conveyor systems to handle sensitive
205 electronic components. These electrostatic phenomena pose a direct threat to data integrity,
206 hardware reliability, and operational continuity.

207

208 4.1 ESD in Data Centers

209 4.1.1 *Damage to Sensitive Equipment*

210 Data centers are filled with high-value, static-sensitive components such as server boards, memory
211 modules, and networking interfaces. Even low-voltage ESD events can cause immediate damage
212 or introduce latent defects that result in premature failure.

213

214 4.1.2 *Data Corruption and System Disruption*

215 ESD events can interfere with the operation of digital systems, potentially leading to bit errors, data
216 corruption, or even file system-level failures. The integrity of data being processed or stored can
217 be compromised, which is unacceptable in mission-critical environments.

218

219 4.1.3 *Downtime and Reliability Risks*

220 Many data centers target "five nines" (99.999%) uptime. ESD-induced component failures
221 undermine this reliability, leading to unplanned outages, service interruptions, and loss of
222 availability.

223

224 4.1.4 *Financial and Reputational Costs*

225 Beyond repair or replacement costs, ESD events can incur significant indirect expenses, including
226 downtime losses, Service Level Agreement (SLA) penalties, and damage to reputation due to
227 service disruption or data loss.

228

229 4.2 Electrostatic Risks from Conveyor Use

230 4.2.1 *Static Generation by Friction (Triboelectric Charging)*

231 Conveyor belts—especially those made of non-conductive materials such as PVC, rubber, or
232 plastic—can accumulate high levels of static charge due to friction. Without proper grounding or
233 ESD-safe design, these systems become sources of ESD events, risking component damage or
234 introduce delayed-onset damage during transport.

235

236 4.2.2 *Charge Accumulation from Non-Conductive Materials*

237 Belts or rollers with insulating properties can retain electrostatic fields, potentially discharging to
238 personnel, nearby equipment, or sensitive devices placed on the conveyor—bypassing the ESD
239 protection of the data center environment.

240

241 4.2.3 Electrostatic Attraction (ESA) and Particulate Contamination

242 Static-charged surfaces attract airborne contaminants such as dust, fibers, or metal particles. ESA
243 can cause these contaminants to settle on electronic assemblies, leading to cooling issues,
244 conductive bridging, or long-term degradation of components.

245

246 4.2.4 Increased Risk with Speed and Movement

247 High-speed conveyors intensify triboelectric charging, increasing the magnitude and frequency of
248 electrostatic buildup. This raises the probability of uncontrolled discharges unless proper ESD
249 controls (such as ionizers, grounded rollers, or dissipative surfaces) are implemented.

250

251 4.2.5 Sensor and Control System Vulnerability

252 ESD events originating from or near conveyors may disrupt proximity sensors, robotic actuators,
253 or control panels, leading to equipment malfunction, process errors, or system stoppages.

254

255 5.0 MITIGATION STRATEGIES

256 Effective ESD and ESA control strategies are essential when using conveyors in data centers.
257 Without proper mitigation, these systems can become significant sources of electrostatic hazards—
258 threatening equipment, data, and overall facility uptime. Implementing ESD-safe materials,
259 grounding protocols, ionization, and continuous monitoring is critical to maintaining the integrity and
260 reliability of data center operations.

261

262 5.1 ESD Controls

263 Implementing ESD control measures such as grounding, using low-charging materials, and
264 ensuring proper humidity levels¹ can help mitigate the risk. Data center personnel often wear wrist
265 straps for personnel grounding and use ESD-safe tools when contacting ESD-sensitive items.

266

267 5.2 ESD Training

268 Training staff in proper handling techniques and the importance of ESD precautions ensures that
269 everyone understands the risks and follows best mitigation practices.

270

271 5.3 Conveyor Design

272 Using conveyors designed with appropriate low-charging materials and incorporating grounding
273 mechanisms can reduce the risk of static build-up. Additionally, ensuring smooth and controlled
274 movement helps prevent physical damage.

275

276 5.4 Environmental Controls

277 Maintaining a clean environment with air filtration systems and regular cleaning schedules can
278 minimize contamination risks associated with conveyors.

279

280 6.0 ESD CONTROL PROGRAMS**281 6.1 ESD Control Program Components**

282 Data centers with ESD control programs typically implement the following measures:

¹ A study was done to show a decrease in humidity may not impact data centers. See "Determination of Effect of Humidity on the Probability of ESD Failure or Upset in Data Centers" paper SE-14-003 from ASHRAE Transactions – Seattle 2014

-
- 283 • **Grounding and Bonding:** Proper grounding of equipment to dissipate static charges safely or
284 use equipotential bonding to avoid dangerous potential differences.
- 285 • **ESD-Safe Workstations:** Use of ESD control elements, such as ESD mats, wrist straps, and
286 ESD-safe tools in areas where sensitive components are handled.
- 287 • **Environmental Controls:** Maintaining optimal humidity levels to reduce static electricity build-
288 up.
- 289 • **ESD Training:** Regular training for personnel on ESD awareness and best practices.
- 290 • **Monitoring and Testing:** Continuously monitor electrostatic conditions in critical areas and
291 regularly test all ESD control equipment (such as wrist straps, grounding systems, and ionizers)
292 to ensure they are functioning properly and within specified limits.

293

294 **6.2 Examples of Data Centers with ESD Programs**

295 By addressing ESD and ESA concerns, data centers can maintain the integrity and reliability of
296 their operations, ensuring the safety of their equipment and the continuity of their services.

297 It is well-known that many leading data center operators implement ESD control programs as part
298 of their standard operating procedures. Below are types of data centers likely to have robust ESD
299 control measures and some of the major operators of each type.

300

301 **6.2.1 Hyperscale Data Centers**

302 6.2.1.1 Examples

- 303 • Amazon Web Services (AWS)
- 304 • Google Cloud
- 305 • Microsoft Azure
- 306 • Facebook
- 307 • Apple

308

309 6.2.1.2 ESD Control

310 These companies operate vast data centers with stringent environmental controls, including ESD
311 prevention measures to protect their extensive hardware investments.

312

313 **6.2.2 Colocation Providers**

314 6.2.2.1 Examples

- 315 • Equinix
- 316 • Digital Realty
- 317 • CyrusOne
- 318 • CoreSite
- 319 • NTT Global Data Centers

320

321 6.2.2.2 ESD Control

322 Colocation providers host equipment for multiple clients and must maintain high standards,
323 including ESD control, to ensure equipment reliability and safety.

324

325 **6.2.3 Enterprise Data Centers**

326 6.2.3.1 Examples

- 327 • IBM Data Centers
- 328 • Oracle Data Centers

-
- 329 • SAP Data Centers
- 330 • HP Enterprise Data Centers
- 331
- 332 6.2.3.2 ESD Control
- 333 Large enterprises manage their own data centers and implement ESD control programs to protect
- 334 their critical infrastructure and data.
- 335
- 336 **6.2.4 Telecommunications Data Centers**
- 337 6.2.4.1 Examples
- 338 • AT&T Data Centers
- 339 • Verizon Data Centers
- 340 • CenturyLink Data Centers
- 341 • Deutsche Telekom Data Centers
- 342
- 343 6.2.4.2 ESD Control
- 344 Telecommunications companies operate data centers critical for their network services,
- 345 necessitating stringent ESD controls.
- 346
- 347 **6.2.5 Government and Military Data Centers**
- 348 6.2.5.1 Examples
- 349 • Department of Defense (DoD) Data Centers
- 350 • National Security Agency (NSA) Data Centers
- 351 • Government Accountability Office (GAO) Data Centers
- 352
- 353 6.2.5.2 ESD Control
- 354 Government and military data centers handle sensitive information and must ensure the highest
- 355 levels of reliability and security, including ESD control.
- 356
- 357 **7.0 BEST PRACTICES FOR USING CONVEYORS IN DATA CENTERS**
- 358 **7.1 Material Selection**
- 359 • **ESD-optimized Materials:** Use materials for conveyor belts and structures that have low-
- 360 charging properties. This includes belts made from conductive or static-dissipative materials.
- 361 • **Grounding:** Ensure that all metallic parts of the conveyor system are properly grounded to
- 362 dissipate static charges.
- 363
- 364 **7.2 Grounding and Bonding**
- 365 • **Continuous Grounding:** Install grounding points at regular intervals along the conveyor
- 366 system.
- 367 • **Bonding Straps:** Use bonding straps to connect different parts of the conveyor, ensuring there
- 368 are no isolated conductive parts.
- 369
- 370 **7.3 Environmental Controls**
- 371 • **Humidity Control:** Maintain an optimal humidity level (typically 40-60%) to reduce static
- 372 buildup. Humidity control systems can be integrated into the data center's HVAC system.
- 373 • **Ionization:** Use ionizing blowers or bars to neutralize static charges on non-conductive
- 374 materials or surfaces.

375

376 7.4 Operational Procedures

- 377 • **ESD Training:** Train staff on ESD awareness, proper handling techniques, and the importance
378 of ESD controls.
- 379 • **Handling Procedures:** Implement procedures for handling and transporting sensitive
380 equipment, ensuring it is not placed directly on potentially charged surfaces.

381

382 7.5 Monitoring and Maintenance

- 383 • **ESD Monitoring:** Regularly monitor ESD levels in the conveyor system using ESD meters and
384 other monitoring devices.
- 385 • **Maintenance Checks:** Conduct routine maintenance checks to ensure that all grounding and
386 bonding connections are secure and that the conveyor system is functioning as intended.

387

388 8.0 CONCLUSION

389 While specific details about individual data centers' ESD control programs might not be publicly
390 available due to security and proprietary reasons, leading data center operators across various
391 sectors are known to implement comprehensive ESD control measures to protect their
392 infrastructure and ensure operational reliability.

393

394 9.0 RELEVANT INDUSTRY STANDARDS AND CERTIFICATIONS

395 There are standards and best practices that data centers can follow to mitigate ESD issues when
396 using conveyors. These standards ensure that the design, installation, and operation of conveyors
397 minimize the risk of ESD damage to sensitive electronic equipment.

398

399 9.1 ANSI/ESD S20.20 and IEC 61340-5-1

400 This standard provides a comprehensive outline for developing an ESD control program to protect
401 electronic components. While it doesn't specifically focus on conveyors, the principles can be
402 applied to conveyor systems in data centers.

403

404 Key Points:

- 405 • Establishing an ESD control program.
- 406 • Grounding and bonding requirements.
- 407 • ESD-safe handling procedures and training.

408

409 9.2 ISO 14644-1 and ISO 14644-2

410 These standards pertain to cleanroom environments, which can overlap with data center
411 environments where ESD control is critical.

412

413 Key Points:

- 414 • Cleanroom classification and requirements.
- 415 • Monitoring and testing procedures for particulate control.
- 416 • These guidelines help ensure a contamination-free environment, which can help reduce ESD
417 risks.

418

419 9.3 ESD TR53®

420 This document provides standardized compliance verification procedures and troubleshooting
421 guidance for testing equipment and setups used in verifying ESD control items (such as wrist

422 straps, grounding systems, ionizers, flooring, garments, etc.) within ESD control programs like
423 ANSI/ESD S20.20. It establishes baseline testing routines to detect performance degradation over
424 time.

425

426 **Key Points:**

- 427 • Comprehensive compliance verification scope.
- 428 • Baseline and ongoing testing with troubleshooting.
- 429 • Flexible adaptation for organizational needs.