

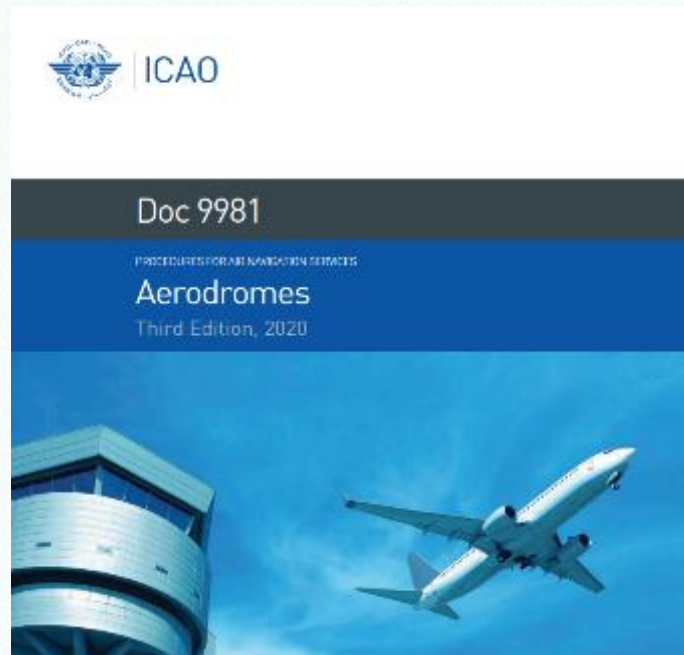
Effects of adverse weather on airport operations

Aerodrome Manual

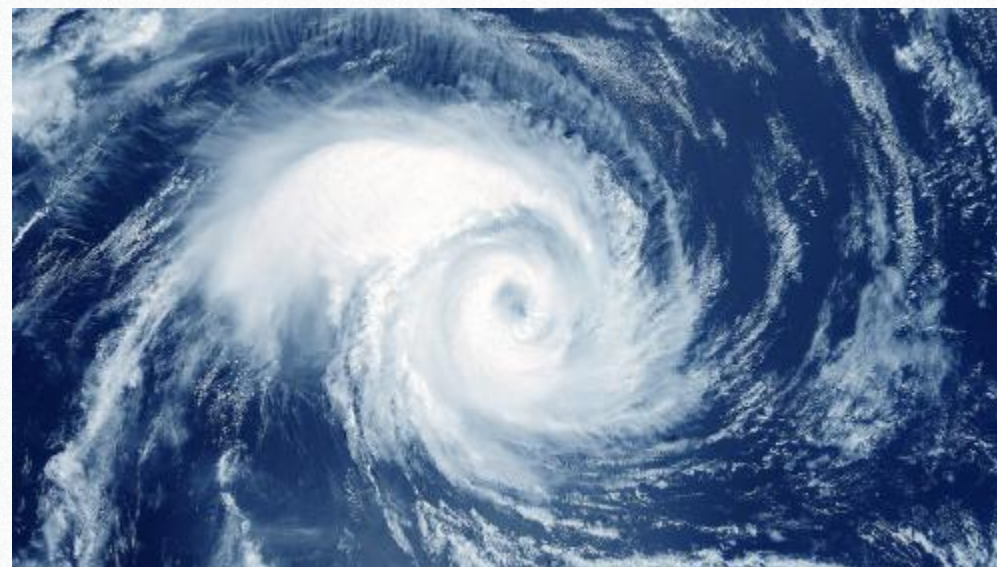


Manual de aeródromo

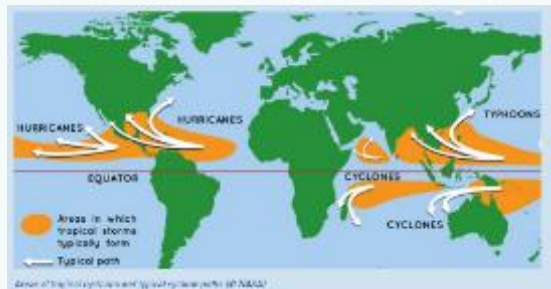
- Doc 9981 – ICAO
- Operator-defined procedures in coordination with ATC and airlines
- Infrastructure and protocols according to AAC regulations
- Severe weather: operational risk, damage and possible closures



Tropical cyclones



Tropical cyclones



Typhoon Jebi at Kansai Airport – 2018

- Total interruption of operations for almost 2 weeks
- Main runway flooding



Wind shear, gusts and crosswinds



Wind shear

- Runway Excursion Risk
- Wind variations = danger on landing
- Manufacturer limits can be exceeded
- Pilots depend on the indicator on the ground



Doc 9981 – Attachment B to Chapter 8 (a), 3.3.3 (I)

Doc 9981 – Appendix to Chapter 4, 5.3 (b)

Doc 9981 – Appendix to Chapter 4, 2.5.1.4 Note 2.5.1.7 (c)

Wind shear

2431 Aeromexico Connect at Durango International Airport, Mexico – 2018

- Obstacles = severe damage to the aircraft
- Ditches and potholes aggravate the risk
- Prevention: clean and level track and grassy areas free of obstacles



Gusts of wind

- Aircraft displaced by gusts
- Collision with structures and equipment
- Risk to staff on the platform
- Damage to hangars and terminals



Gusts of wind

- Special inspection after high winds
- Trailing FOD Assessment
- Waste and mud in critical areas
- Strategic location in the face of winds

ICAO Doc 9981 – Chapter 3, 3.1.7 (d)

ICAO Doc 9981 - Appendix 2 to Chapter 5, 1.5



Aeroporti di Roma		Report of Anomalies Adverse weather conditions		Date	Inspection start time	End of inspection time
DATA OF THE EMPLOYEE AND THE SUPERVISOR						
Surname Assigned	Employee Signature	Surname Supervisor	Supervisor Signature			
Area under inspection: Apron ☐ Maneuvering Area ☐						
☐ SECTION 1 - CHECK IN CASE OF STRONG WIND						
Weather alert communicated by:						
Anomalies found		Description of anomalies found during the inspection				
1		Material in construction sites not anchored				
2		Vehicles, equipment, and materials of the handlers not safe				
3		ACFT parked, lack of heels				
☐ SECTION 2 - CHECK IN CASE OF HEAVY RAIN						
Weather alert communicated by:						
Conditions to be monitored		Description of anomalies found during the inspection				
1		Runway and taxiway, presence of stagnation				
2		Runway strip and taxiway, presence of stagnation				
3		Apron taxiway, presence of stagnation				
4		ACFT stand, presence of stagnation				
NOTES / FURTHER ANOMALIES TO REPORT						

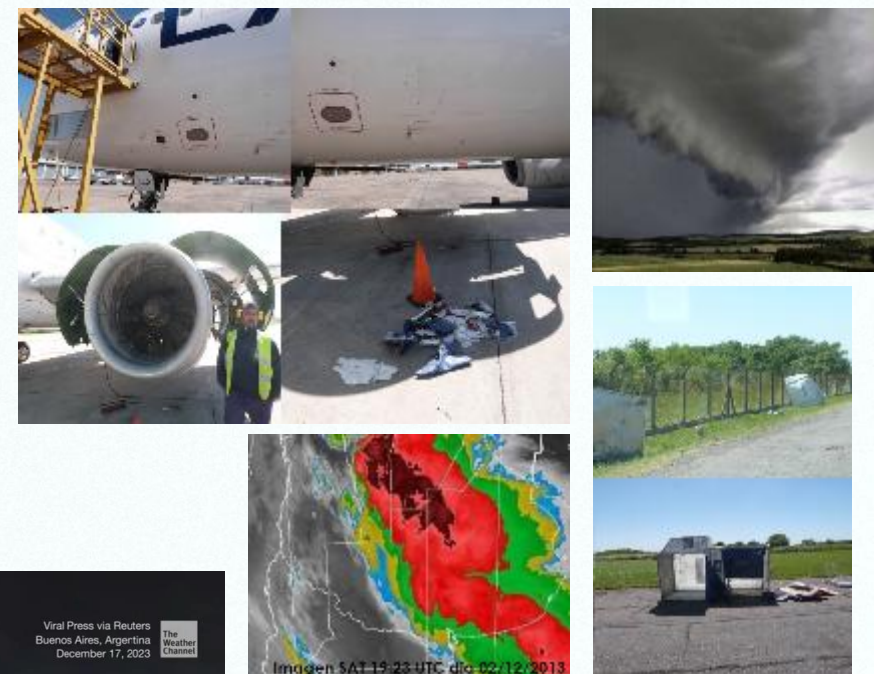


Figure 1-11. Common tie-down points.

Gusts of wind

Ezeiza International Airport, Argentina, on December 2, 2013

- Extreme gusts up to 130 km/h
- Two aircraft damaged (A320 and A321)
- 20°C drop in 12 hours
- Wind: 12 kt to 70 kt in 1 hour



Argentina, December 2023

- Gusts of up to 140 km/h
- Aircraft dragged at three airports
- Damage to platforms and structures
- 135 flights cancelled



Gusts of wind

- Clear alerts and predefined channels
- Sensors: validation and legal support
- Strategic location to avoid interruptions
- Prague Václav Havel Airport (PRG)
SOP: actions according to wind intensity
- Aircraft, equipment and passenger protection
- Bridges and cargo: Suspended operations if necessary

Staff Actions	25–39 kt 46–72 km/h	40–59 kt 73–110 km/h	>60 kt >111 km/h
Chock aircraft landing gear as per Aircraft Out of Service/Night-Stop/High Wind	✓	✓	✓
Remove safety cones	✓	✓	✓
Secure PCA hoses	✓	✓	✓
Remove FOD	✓	✓	✓
Secure ULDs	✓	✓	✓
Secure rolling stock	✓	✓	✓
Strap all propellers on propeller aircraft	✓	✓	✓
Secure PBB and position to minimize surface exposed to the direct force of the wind		✓	✓
Close cargo holds, passenger doors, and access panels		✓	✓
Do not initiate the elevation of high-lift equipment and stairs		✓	✓
Park GSE closely together, and adjacent to a building if possible			✓
Retract PBB			✓



Gusts of wind

- Breaks in the perimeter fence
- Risk of incursion or collision with fauna
- Withstand strong gusts
- Reinforce structure in the face of severe events
- Monitoring of weather conditions

Issyk-Kul International Airport (Kyrgyzstan, 2024)

- Gusts knock down 90 m of perimeter fence
- Direct risk to operational safety



L.F. Wade International Airport (Bermuda, 2010)

- Strong winds damage perimeter fence
- Entire sections were destroyed



Sandstorms



Sandstorms

- Reduced visibility and operational risk
- Sand accumulated in tracks and drainage
- Cover aircraft entrances and vents
- Use of masks and eye protection
- Frequent cleaning and preventative maintenance

Baghdad International Airport (Baghdad, 2022)

- Reduced visibility and cancelled flights
- Orange-red sky by dense cloud
- Winds dragged sand for hundreds of km
- Serious impacts on BGW operations



High temperatures



High temperatures

- Aircraft and equipment performance
- Heat stress and infrastructure design
- Reduced flexible flooring life
- Design must consider extreme thermal changes
- Changes in bird migratory routes
- Alterations in reproductive periods



Extreme events in recent years

Period	Airport	Event Occurred	Operational Impact
Jul 2019	Heathrow, Gatwick, City	NATS radar failure after heat wave + storms	Air traffic restrictions, delays, cancellations
Jul 2022	Luton	Runway pavement "melted" due to extreme heat	Complete flight suspension until runway pavement repair
Jul 2022	RAF Brize Norton	Extreme heat damaged runway pavement	Military flights temporarily suspended
Jul 2022	Heathrow and Gatwick	Heat + storms after heat wave	Significant delays and cancellations



Low temperatures

Snow

Ice

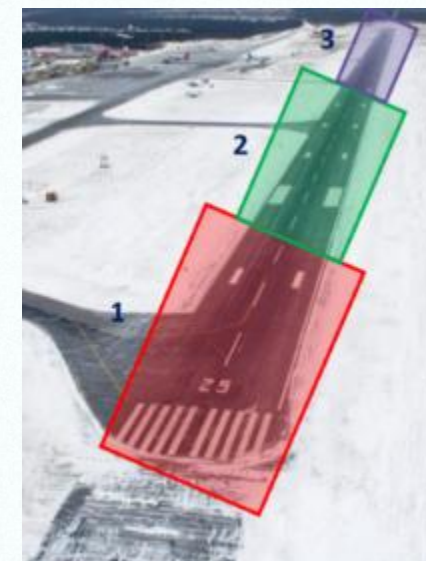
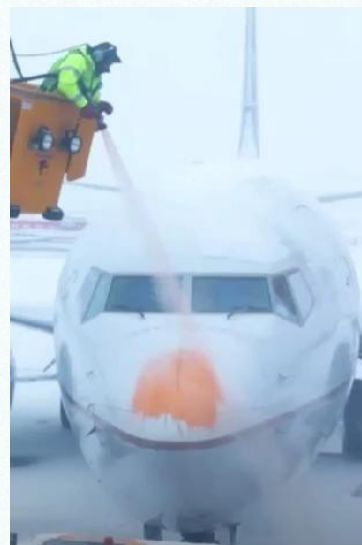


Low temperatures and snow

- Freezing, cold exposure
- Accumulation snow, cable failure
- Restriction of visibility, RWY excursion
- Whitening effect
- Critical infrastructure heating, de-icing
- Runway Condition Code (GRF)

Extreme events in recent years

Year	Airport	Interruption Duration	Accumulated Snow
2022	Istanbul (IST)	More than 36 h	50-80 cm
2022	Buffalo (BUF)	More than 48 h	~120 cm
2016	JFK (New York)	48 h	70 cm



**Doc 9981 – Appendix to
Chapter 4, 4.1.6 a)**

Fog



Fog

- Requires infrastructure, crew, and trained ATC
- Low visibility simulation
- SMGCS manual - Doc 9476
- Surface Movement Radar (SMR)

More severe events that have affected airports

Airport / Location	Event Date	Minimum Visibility	Impact on Operations	Available ILS Category
Kolkata, India (VECC)	January 6, 2025	< 50 m	60 flights delayed, 5 diverted, 1 cancelled, terminals saturated	ILS CAT II
Delhi, India (VIDP)	January 11, 2024	0 m (zero visibility)	+400 flights affected, 100 cancelled, operations suspended for 9 hours	ILS CAT III-B
London Heathrow (EGLL)	January 25, 2023	75 m	100 flights cancelled, 120 delayed, diversions to Gatwick and Manchester	ILS CAT III
Shanghai Pudong (ZSPD)	February 7, 2021	< 100 m	200 flights suspended, dozens of international connections affected	ILS CAT II
Chicago O'Hare (ORD)	November 3, 2022	90 m	Operations reduced for 6 hours, widespread delays on domestic and intl. flights	ILS CAT III-A
Beijing Daxing (PKX)	December 19, 2023	100 m	150 flights delayed or cancelled, dependence on CAT III-B for limited landings	ILS CAT III-B
Istanbul (IST)	December 20, 2022	100-150 m	+70 flights affected, runway congestion, long ground delays	ILS CAT III
Dubai Intl (OMDB)	February 28, 2020	~100 m	International flight diverted to Abu Dhabi; 30 flights with more than 2h delays	ILS CAT II



Doc 9981 – Appendix to Chapter 4, 6.6 b) and Annex C to Chapter 2, 5.16

Fog

- Signals in optimal conditions
- Enhanced contrast with contours
- Adaptation to the colour of the pavement
- ARFF in low visibility: fog lights
- Protection of electrical systems during construction sites
- Alert to suspend activities

Doc 9981 – Appendix to Chapter 4, 6.6 b) and Annex C to Chapter 2, 5.16

Biggin Hill Airport (London, 2014)

- Take-off
- Poor signage



Figura 1 – Contornos em sinalizações horizontais de pátio de aeronaves



Luxembourg International Airport (Luxembourg, 2010)

- Maintenance during fog (ILS CAT 3B)
- Collision with maintenance vehicle
- Lack of coordination



Thunderstorms



Thunderstorms

- Ground service interruption
- Risk for ground handling
- 8 km (alert), 5 km (suspension), no lightning = resumption

Doc 9981 – Appendix to Chapter 4, 3.4 a)



Southwest Florida International Airport (RSW) (USA, 2017)



Thunderstorms



More severe events that have affected airports

Airport	Date	Event Type	Main Impact	Interruption Duration	Number of Affected Flights	Affected Passengers / Observations
Viracopos (Campinas), Brazil	Dec 28, 2020	Lightning struck runway	Hole in runway asphalt	~1h05min	9 (8 delays + 1 diversion)	Runway closure for repairs
Guarulhos (São Paulo), Brazil	Jan 2025	Lightning struck aircraft	Safety inspection and delays	~6 hours	57 (24 rescheduled, 15 take-offs cancelled, 18 landings cancelled)	Delays due to aircraft inspections and verifications
Leite Lopes (Ribeirão Preto), Brazil	Jan 2023	Lightning struck lighting system	Runway lighting outage	Short	7 cancelled	Flight suspension for safety
Manila (NAIA), Philippines	Jun 2019	Nearby lightning (Red lightning alert)	Preventive suspension of platform operations	As needed	Not specified	Safety measure to prevent accidents



Heavy rains



Heavy rains

- Water accumulation reduces visibility, causes aquaplaning, reduces friction/braking
- Maintenance: friction monitoring, rubber removal, drainage system capacity increases
- Standardized reporting: Global Reporting Format (GRF)



Hewanorra International Airport (Saint Lucia, Caribbean, 2013)



Naval Air Station Jacksonville (Florida/EUA, 2019)



More severe events that have affected airports

Airport	Location	Year	Event	Impacts	Measures / Consequences
Dubai International Airport	Dubai, United Arab Emirates	2024	Historic storm (142 mm in 24h)	Suspension, cancellations and delays	Infrastructure reinforcement and planning
Kansai International Airport	Kansai, Japan	2018	Heavy rains and flooding	Temporary suspension and significant delays	Drainage system improvements
Guarulhos International Airport	São Paulo, Brazil	2020	Heavy rains and external flooding	Delays and logistical difficulties	Urban drainage improvements
Heathrow Airport	London, United Kingdom	2019	Extreme rains and flooding	Delays and parking flooding	Investments in rainwater containment
Ninoy Aquino Airport	Manila, Philippines	2012-21	Frequent storms	Cancellations, delays and infrastructure damage	Emergency plans and drainage improvements
Indira Gandhi Airport	Delhi, India	2020	Monsoons and flooding	Temporary suspension and flight diversions	Implementation of drainage improvements

Heavy rains

Barcelona-El Prat Airport 2024

- Cancellation of more than 70 flights and 17 diversions
- Submerged runway areas



Dubai International Airport 2024

- 164 mm in 24 h
- Runways like rivers



Heavy rains

2024 Porto Alegre Salgado Filho International Airport, Brazil 2024

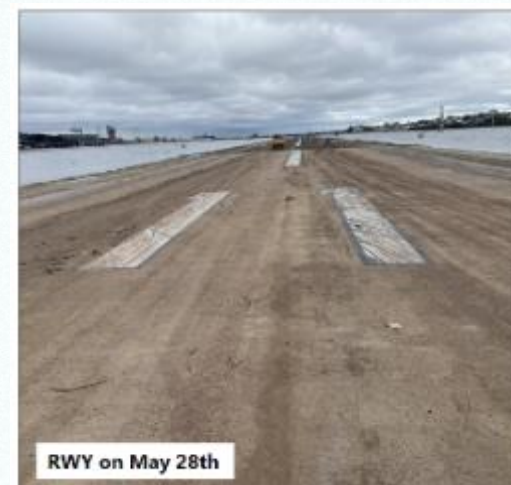
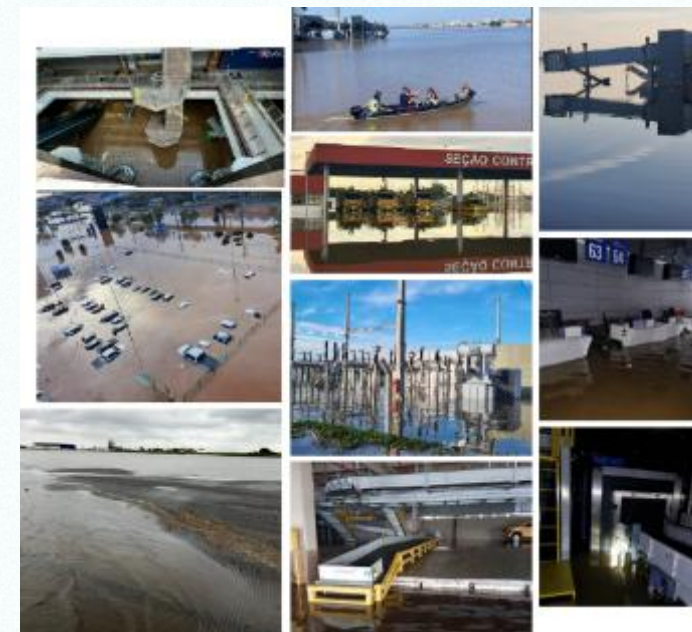
- Rainfall record: 417 mm
- Lake Guaíba exceeded 5.3 m
- Airport under 2.5 m of water
- Insufficient drainage aggravated the impact



Heavy rains

2024 Porto Alegre Salgado Filho International Airport, Brazil 2024

- Runway 2300 m, TWYs, platforms
- 10 substations
- 18 buildings, including 33,000 m² of the ground floor of the Terminal
- 10 x-rays, 11 elevators, 6 escalators
- 15 boarding bridges
- 30% of baggage handling systems
- 4 chillers and pumps (HVAC)
- Furniture
- 7 IT technical rooms
- 200 km of cables
- 150,000 tonnes of asphalt



Heavy rains

2024 Porto Alegre Salgado Filho International Airport, Brazil 2024

- Comparative tests for 45 days
- FWD to simulate aircraft cargo
- Pavement scanner: detailed mapping
- Severe damage from prolonged immersion (23 days)



- Canoas Air Base as an alternative

- Limited parking for aircraft, limited infrastructure, and complex logistics



Heavy rains

2024 Porto Alegre Salgado Filho International Airport, Brazil 2024

- Continuous monitoring by ANAC
- Approvals at key stages of the process
- Temporary adjustments in the Airport Manual
- Checklist for gradual reopening



Heavy rains

2024 Porto Alegre Salgado Filho International Airport, Brazil 2024

- More birds, caracaras, capybaras and foxes
- ANAC demanded mitigation plan from the operator
- Lawn mowing, drainage, and reinforced fencing
- 481 animals removed (239 live)
- Intensified monitoring and control after the flood



Figura 12 – Serpente (Dipsosaurus dorsalis) removida no terminal de passageiros durante atividades de limpeza.



Figura 13 – Capivara (Capybara) removida durante limpeza do canal de drenagem.



Contingency planning



Contingency planning

- ACRP Report 65: tools and operational checklists
- Designation of officers and response committees
- Collaborative management
- Operational resumption: risk analysis and validation by authorities

**Doc 9981 – Appendix
to Chapter 4, 3.4 b)**

Aspect	Emergency Plan	Weather Management Plan
Type of event	Natural disasters (earthquakes, floods)	Adverse weather conditions (rain, fog)
Impact	Severe damage to people and infrastructure	Operational risks not always with structural damage
Response	Multisectoral and extervention	Internal coordination at the airport
Meteorological service	Not always involved	Active participation and alert communication

Airport Weather Management Plan

1. **Awareness:** Forecasts, activation, decision-making
2. **Management:**
 1. Preparation
 2. Communication and alerting
 3. Response coordination
 4. Return operations
 5. Performance review/adjustments



Airport resource	04:00	05:00	06:00	06:10	06:30	07:00	08:00	09:00
RWY 06	ICE	ICE	ICE	ICE	ICE	GRADE ICE	GRADE ICE	GRADE ICE
RWY 12	ICE	ICE	ICE	ICE	ICE	GRADE ICE	GRADE ICE	GRADE ICE
RWY 34	ICE	ICE	ICE	ICE	ICE	GRADE ICE	GRADE ICE	GRADE ICE
RWY 30	ICE	ICE	ICE	ICE	ICE	GRADE ICE	GRADE ICE	GRADE ICE
TWRs	ICE	ICE	ICE	ICE	ICE	GRADE ICE	GRADE ICE	GRADE ICE
Stands	ICE	ICE	ICE	ICE	ICE	GRADE ICE	GRADE ICE	GRADE ICE
Handling	TEMP ICE	TEMP ICE	TEMP ICE	TEMP ICE	TEMP ICE	TEMP ICE	TEMP ICE	TEMP ICE
Airbridges	ICE	ICE	ICE	ICE	ICE	ICE	ICE	ICE
VDS	RVR	RVR	RVR	RVR	OK	OK	OK	OK
Powerback	VIS	VIS	VIS	VIS	VIS	OK	OK	OK



Airport weather management plan



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