

Fabric Waviness

Supply Chain Investigation and Corrective Action

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Scope	Yarn to finished garment
Prepared for	Supplier and factory technical teams
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1 Executive summary

This case concerns 8,760 m of 95% cotton/5% elastane single-jersey fabric received in 42 rolls during the monsoon season. Twenty-eight rolls representing 5,840 m developed edge and center waviness after unwinding and relaxation. Under the normal 180 cm marker, matching leg panels differed by 8–22 mm along critical inseams and side seams and could not be stitched consistently without forced stretching, excessive easing or unauthorized trimming.

Fabric waviness may be generated during yarn preparation, weaving or knitting, wet processing, drying, stentering, compaction or winding. It may remain restrained in a roll and become visible after transport, monsoon humidity exposure, warehouse storage, unwinding, conditioning, relaxation, cutting, heat or moisture. Factory handling can also amplify the effect. The stage at which waviness appears does not by itself identify the responsible party.

Investigation confirmed that cross-width overfeed imbalance during compacting created unequal residual length, while excessive and inconsistent winding tension restrained the condition inside the roll. Monsoon humidity activated the stored strain after opening. A factory practice of releasing fabric after only 12 hours of relaxation amplified panel variation but did not generate the original cross-width instability. The supplier owned the primary manufacturing correction; the factory owned its relaxation and release-control correction.

After roll mapping and trials, 4,960 m were released for a 168 cm narrow marker, 420 m were released through removal of mapped sections, 260 m were rejected and replaced, and 200 m were consumed by trials and controlled cutting loss. Pilot and bulk garments met dimensional and appearance requirements. Three subsequent lots totaling 25,460 m showed no recurrence.

Image placeholder — Fabric waviness supply-chain overview infographic

2 Introduction

2 1 Definition

Fabric waviness is an out-of-plane or in-plane irregularity that prevents fabric from lying in a stable, uniform geometry under specified relaxed conditions. It can appear as edge waves, center waves, transverse ripples, longitudinal ripples, local corrugation, bagging or latent waves that emerge after environmental or mechanical release.

“Waviness” is the technical term used in this report. Bow, skew, curl, crease, spirality and seam puckering are related observations or downstream defects and must be measured separately.

Waviness class	Typical appearance	Mechanism investigate to	Garment risk
Edge wave	Loose repeating edges with a flatter center	Edge-center length difference, selvage or needle-line behavior, stenter or winding strain	Reduced usable width and unstable spreading
Center wave	Raised or loose center with firmer edges	Unequal overfeed, cross-width tension or drying	Panels distort within normal marker

Waviness class	Typical appearance	Mechanism investigate to	Garment risk
Transverse ripple	Waves across the width	Length strain, winding pressure or relaxation bands	Panel length varies along roll
Longitudinal ripple	Waves in machine direction	Cross-width tension or length imbalance	Left-right component mismatch
Local corrugation	Short wrinkles or ridges	Compaction, chemistry, moisture or handling variation	Random panel defects
Latent waviness	Appears after rest, humidity, heat, wash or cutting	Stored strain or dimensional instability	Incoming inspection may miss it

2.2 Why waviness is critical

Waviness can reduce usable width, lower marker efficiency, change panel dimensions after cutting, create mismatched seam lengths, twist garment legs or bodies, distort hems and pockets, cause sewing stoppages and rework, and reappear after washing or pressing.

2.3 Three event model

1. Generation: A process creates nonuniform structure, length or stored strain.
2. Activation: Transport, humidity, storage, relaxation, heat, moisture or cutting allows the difference to appear.
3. Amplification: Factory spreading tension, lay pressure, delayed relaxation or handling increases its effect.

A monsoon-period observation is evidence for investigation, not proof that humidity caused the defect. High humidity may change moisture regain or release earlier strain; leakage or condensation may unevenly wet the roll. This must be tested using exposure evidence and controlled comparisons.

Image placeholder — Actual affected fabric roll showing wave direction and zones

Image placeholder — Generation activation and amplification diagram

3 Present status and current condition

3.1 Confirmed observations

- Waviness is associated with normal-width cutting.
- Matching panels show length variation or high-low edges.
- Normal assembly is not consistently possible.
- Narrow-marker cutting has been proposed with supplier involvement.

- Twenty-eight of 42 rolls were affected; the strongest waves occurred within 0–9 cm of both edges and intermittently within the center 12 cm.
- Normal-marker panel mismatch was 8–22 mm; the approved narrow-marker route reduced mismatch to 0–3 mm after 24-hour panel rest.
- Bulk recovery produced 9,684 garments; 37 were rejected for waviness-related shape or seam mismatch, equal to 0.38%.

3 2 Required case register

Field	Required entry
Supplier, PO, fabric article and garment style	Names omitted; PO-SIM-26017; Article SJ-CEL-180; slim-fit stretch trouser
Fiber, yarn, construction, GSM, finish and stretch	95% combed cotton/5% elastane; 30/1 compact yarn; single jersey; 180 ± 5% GSM; reactive dyed and compacted
Normal finished width and marker width	Finished open width 185 ± 2 cm; normal marker 180 cm
Roll IDs, batches, colors and total quantity	R001–R042; one dye batch; dark navy; 8,760 m
Affected roll IDs, meters and zones	R003–R030; 5,840 m; both edges 0–9 cm and intermittent center band of 12 cm
Storage and transit dates including monsoon period	Dispatched 04 June 2026; received 08 June; stored 8–12 June; RH 78–91% during transit/receipt
Normal-marker panel measurements	Critical mating mismatch 8–22 mm after 24-hour panel rest; requirement ≤4 mm
Narrow-marker trial widths and results	172, 170 and 168 cm tested; 168 cm produced 0–3 mm mismatch and stable geometry
Garment trial and care results	60 garments; passed sewing, wash, tumble dry, press and 24-hour rest; no leg twist above 1.0%
Supplier agreement and claim reference	SIM-RA-017; supplier accepted excess consumption, replacement and verified recovery costs

3 3 Severity classification

Use the approved customer or company defect standard. Until those limits are entered, classify stock operationally:

Status	Meaning	Permitted action
HOLD	Assessment incomplete	Inspection and controlled trials only
NORMAL RELEASE	Normal-width route passes	Normal production
NARROW-MARKER RELEASE	Specified roll zone and recovery route pass	Restricted production only

Status	Meaning	Permitted action
REPROCESS	Supplier treatment is approved for trial	Requalify before cutting
REJECT	Recovery is inconsistent or requirements fail	Return, replace or agreed disposition

3 4 Immediate containment

Factory QA shall hold all implicated rolls, cut bundles and traceable garments. Warehouse shall block stock issue. Cutting shall preserve failed panels, marker files and lay records. Supplier QA shall provide yarn-to-dispatch traceability, retained samples and actual process records.

Image placeholder — Actual defect photographs with roll meter and width position

Image placeholder — Affected quantity and defect-rate chart

4 Background and history

The simulated supply chain used compact-spun 30/1 cotton yarn with elastane, circular knitting, open-width preparation, reactive dyeing, stenter drying, open-width compacting and roll winding. Fabric was polyethylene wrapped, road transported for four days and received during monsoon conditions. No earlier claim existed for the same article, although the supplier's internal audit found one previous compactor overfeed alarm that had been reset without a documented fabric hold.

4 1 Yarn and material history

Yarn count, twist, evenness, strength, elastane specification and feeder records were reviewed. All 42 rolls used the same approved yarn and elastane lots. Retained greige samples were flat after relaxation, and no correlation existed between feeder position and affected zones. Yarn and elastane variation were therefore eliminated as root causes.

4 2 Fabric formation history

Knitting records showed stable stitch length, take-down and elastane feed. Greige width and course density were within control limits at five cross-width positions. Both affected and unaffected finished rolls came from the same knitting machine, while the defect correlated with one finishing and winding sequence. Fabric formation was therefore not identified as the generating stage.

4 3 Wet processing and finishing history

The stenter records were within approved limits. Compactor records for rolls R003–R030 showed a 17-minute left-right overfeed deviation after a sensor change: operator-side overfeed averaged 18.6% while drive-side overfeed averaged 14.1%, against a $16\% \pm 1.5\%$ target. Cross-width residual shrinkage later measured from 2.1% to 5.8%. The deviation was not linked to a hold because the alarm-reset procedure did not require material segregation.

4 4 Winding delivery and storage history

Winding tension for affected rolls varied from 31 to 43 N against the approved 28–32 N range, and left-right roll hardness differed by 6–11 points. Packaging was intact, with no leakage or direct wetting. Transit and receipt RH ranged from 78% to 91%. Outer-layer moisture regain was 8.7%, compared with 7.4% in inner layers. Humidity accelerated release of stored strain, but controlled reconditioning showed that it did not create waviness in conforming reference rolls.

Image placeholder — Fabric identification and supplier lot tags

Image placeholder — Yarn-to-garment process timeline

5 Methodology

5 1 Case selection

This case is selected because fabric behavior prevents consistent use of the normal marker and directly threatens garment conformity, material yield and delivery. The risk is elevated where the defect varies by roll or emerges only after release.

5 2 Data triangulation

A cause is accepted only when supported by more than one relevant source.

Evidence stream	Examples	Purpose
Material evidence	Retained samples, affected rolls, cut panels and garments	Show the physical defect and response
Process evidence	Machine settings, alarms, batch cards and operator records	Link behavior to a process event
Environmental evidence	Temperature/RH logs, packaging, leak or condensation records	Test transport and monsoon hypotheses
Measurement evidence	Width-zone, panel, shrinkage and garment results	Quantify magnitude and repeatability
Human evidence	Supplier and operator interviews	Identify deviations for documentary verification
Reference evidence	Conforming roll or batch under equivalent conditions	Separate systemic method effects

Image placeholder — Triangulation diagram

5 3 Sampling protocol

Select affected and unaffected rolls across implicated batches. Within a roll, sample beginning, middle and end and mapped abnormal locations. Across the width, use left edge, left-

intermediate, center, right-intermediate and right edge where needed. Include outer, middle and inner roll layers for environmental or storage investigation.

Record roll ID, meter position, width position, roll layer, conditioning, whether restrained, date, temperature and relative humidity where relevant. Expand sampling if variability exceeds the initial design.

5.4 Study protocol

1. Verify fabric, pattern and marker identity.
2. Photograph and classify waviness on a flat surface without pulling it smooth.
3. Compare roll-on-machine, immediately unwound and conditioned states.
4. Measure fabric zones and normal-marker panels before and after defined rest.
5. Repeat using conforming reference fabric.
6. Test candidate narrow-marker zones while controlling spreading variables.
7. Assemble pilot garments.
8. Apply actual fusing, washing, drying and pressing route.
9. Verify garments after cooling, rest and required care.
10. Repeat the successful route on representative rolls before bulk release.

Use calibrated equipment and the applicable approved methods. ASTM D1776/D1776M provides a conditioning framework when required by a test method; the applicable customer method controls the actual atmosphere.[4]

Image placeholder — Sampling map across roll width and length

Image placeholder — Investigation workflow

6 Findings and evidence summary

6.1 Confirmed factual findings

Twenty-eight consecutive rolls from one finishing and winding sequence showed repeatable edge and center waviness. After 24-hour fabric relaxation, wave amplitude ranged from 9 to 24 mm. Normal 180 cm markers placed long leg panels across unstable zones; after cutting and 24-hour panel rest, mating mismatch ranged from 8 to 22 mm. Fourteen reference rolls from the same knitting and dye batch produced 0–3 mm mismatch.

Controlled tests at 172, 170 and 168 cm showed that only the 168 cm marker consistently excluded unstable edge zones and avoided the intermittent center band through paired placement. Sixty pilot garments cut by this route passed assembly, laundering, pressing and 24-hour post-process rest. The recovery route was therefore technically validated before bulk use.

6.2 Required measurement definitions

- Pattern deviation = measured critical dimension – approved pattern dimension.

- Mating mismatch = seam length A – seam length B – designed difference.
- Panel variation range = maximum – minimum comparable measurement.
- Dimensional change (%) = $100 \times (\text{post-condition length} - \text{initial length}) / \text{initial length}$.
- Usable-zone yield (%) = $\text{approved usable area or length} \div \text{inspected area or length} \times 100$.

6 3 Process impact assessment

Process	Impact of waviness	Immediate control	Owner
Inspection	Machine tension can hide waves	Inspect defined relaxed state	Supplier/factory fabric QA
Storage issue	Mixed status rolls enter production	Physical and system hold	Warehouse and QA
Relaxation	Zones change length differently	Map zones and stability	Fabric QA/technical
Spreading	Tension temporarily flattens or distorts	Minimum validated tension	Cutting manager
Marker planning	Full width includes unstable zones	Zone-specific marker	CAD/technical
Cutting	Strain release changes panel geometry	Measure after defined rest	Cutting QA
Bundling	Incompatible panels become mixed	Preserve roll-zone-lay traceability	Cutting production
Sewing	Mating edges fail	Stop; do not stretch to fit	Sewing/inline QA
Fusing	Heat reveals distortion	Validate after cooling	Fusing QA
Washing/drying	Moisture and heat activate strain	Trial exact route	Laundry QA
Pressing	Temporary flatness conceals return	Inspect after cooling/rest	Finishing QA
Final inspection	Shape, hem and seam failures	Trace to recovery route	Final QA

6 4 Representative measured results

Roll/zone	Condition	Waviness class	Normal-marker mismatch	Narrow-marker mismatch	Garment result	Decision
R003 / start	24 h relaxed	Edge wave	18 mm	2 mm	Pass	168 cm marker

Roll/zone	Condition	Waviness class	Normal-marker mismatch	Narrow-marker mismatch	Garment result	Decision
R008 middle /	24 h relaxed	Edge + center wave	22 mm	3 mm	Pass	168 cm paired placement
R017 / end	24 h relaxed	Transverse ripple	15 mm	2 mm	Pass	168 cm marker
R026 middle /	24 h relaxed	Center wave	20 mm	3 mm	Pass	168 cm paired placement
R030 / end	24 h relaxed	Edge wave	12 mm	1 mm	Pass	168 cm marker
R035 reference /	24 h relaxed	None	2 mm	2 mm	Pass	Normal release

Image placeholder — Fabric and panel measurement table screenshot

Image placeholder — Cross-width waviness heat map

Image placeholder — Normal versus narrow-marker comparison chart

7 Root cause analysis

7 1 Fishbone categories

- Material: yarn, elastane, construction, finish and component compatibility.
- Machine: formation, transport, stenter, dryer, compactor, winding, spreading and cutting equipment.
- Method: recipe, tension, overfeed, width, relaxation, stacking, marker and lay method.
- Environment: heat, relative humidity, condensation, leakage and seasonal exposure.
- Measurement: inspection tension, sampling bias, uncalibrated equipment and inconsistent conditioning.
- People: undocumented adjustment, handling, status release and escalation failure.

Image placeholder — Fishbone diagram

7 2 Validated Five Whys

Why level	Question	Evidence required	Answer status
1	Why did panels become high-low?	Panel-zone measurements	Panels crossed zones with unequal residual length and changed 8–22 mm after cutting

Why level	Question	Evidence required	Answer status
2	Why did fabric zones respond differently?	Relaxation and dimensional results	Cross-width residual shrinkage varied from 2.1% to 5.8%
3	Why was nonuniform strain present?	Supplier comparison process	Compactor overfeed differed by 4.5 percentage points across width; winding tension exceeded limit
4	Why did controls not prevent or detect it?	Control plan and inspection evidence	Alarm reset did not trigger hold; inspection occurred under tension before full relaxation
5	Why did the system allow release?	Responsibility and release review	Supplier release lacked relaxed-flatness criteria; factory used a 12-hour generic relaxation rule

7.3 Cause and responsibility matrix

Potential cause	Evidence needed	Responsible party if confirmed	Corrective action
Yarn/elastane inconsistency	Lot and zone correlation	Yarn supplier/fabric mill incoming QA	Correct material control and validate new fabric
Weaving/knitting variation	Machine, shift and greige evidence	Fabric formation mill	Correct formation settings/equipment
Wet-processing tension	Linked before/after evidence	Wet-processing mill	Equalize and reduce tension
Stenter/drying variation	Cross-width results and settings	Finishing mill	Correct width, overfeed, tension or drying
Compaction variation	Compaction, moisture and chemistry evidence	Finishing mill	Correct compaction and application
Tight/unequal winding	Unwinding/rest comparison	Supplier winding	Correct tension and package format
Inadequate dispatch protection	Dispatch/arrival evidence	Supplier logistics	Correct stabilization and packaging
Container leakage/handling	Condition or logger evidence	Transport party under agreement	Correct transport controls
Warehouse environment	Logs, leak and comparative evidence	Factory warehouse	Correct environment and requalify
Inadequate relaxation/spreading	Controlled factory trials	Factory cutting preparation	Validate handling conditions

Potential cause	Evidence needed	Responsible party if confirmed	Corrective action
Cutting inaccuracy	Reference-fabric/equipment evidence	Factory cutting	Correct method/equipment
Mixed contribution	Staged or factorial evidence	Shared by verified contribution	Each owner corrects controlled factor

7.4 Validated causes and responsibility

Primary generating cause — supplier finishing: Compactor cross-width overfeed imbalance created unequal residual length. The alarm history, actual setting data, cross-width shrinkage pattern and retained-material reproduction supported this conclusion.

Secondary restraining cause — supplier winding: Excessive and inconsistent winding tension held the unstable geometry inside the roll and delayed visible detection. Tension records, roll-hardness differences and immediate-versus-relaxed comparisons confirmed this contribution.

Activation factor — monsoon humidity: High RH increased moisture regain and accelerated strain release. It was not the root cause because conforming reference rolls exposed to the same controlled humidity remained flat.

Factory amplification and escape cause: Fabric was released after a generic 12-hour relaxation period, although stability was not reached until 24–36 hours, and no critical-panel rest check existed. The factory owned this control failure but did not generate the original instability.

Eliminated causes: Yarn and elastane lots, knitting settings, cutting-machine accuracy, pattern scale and sewing feed were verified within requirements.

Technical responsibility was assigned to the supplier for generation and winding restraint and to the factory for inadequate relaxation and detection. The supplier accepted fabric replacement, excess marker consumption and agreed recovery costs; the factory absorbed its internal retraining and SOP-control cost.

Image placeholder — Validated root-cause evidence panel

8 Corrective actions

8.1 Supplier immediate correction

- Hold related stock and provide complete traceability.
- Review retained samples and actual process records.
- Inspect rolls in relaxed condition.
- Trial reprocessing only on identified material.
- Correct confirmed formation, wet-processing, finishing or winding cause.
- Requalify appearance, width, GSM, shade, strength and stretch/recovery as applicable.

8 2 Transport and monsoon correction

- Quarantine wet, damaged or condensation-exposed rolls.
- Preserve packaging and container evidence.
- Correct moisture barrier, container inspection, roll support and strap pressure.
- Use environmental logging where agreed for risk routes.
- Do not release exposed material because it has become visually dry.

8 3 Factory storage correction

- Repair leakage or condensation sources.
- Restore environmental monitoring and stock separation.
- Compare outer/middle/inner roll layers and mapped width zones.
- Condition and requalify exposed material under an approved procedure.

8 4 Cutting and affected quantity correction

1. Reconcile and block the affected quantity.
2. Map defect and usable zones roll by roll.
3. Develop normal-marker baseline.
4. Trial narrower widths and placement by roll group.
5. Measure panels after defined rest.
6. Make pilot garments and complete the actual process route.
7. Release only documented roll-zone-marker combinations.
8. Reject or return inconsistent material.

Recovery priority	Route	Release requirement
1	Normal marker	Stable across normal usable width
2	Narrow marker	Zone, width, placement and garment trial pass
3	Remove mapped sections	Remaining sub-roll is traceable and requalified
4	Supplier reprocess	Complete requalification passes
5	Restricted component	Specific component and garment are validated
6	Reject/replace	Reliable recovery cannot be demonstrated

Do not pull fabric flat, trim one panel simply to match another, reduce seam allowances without approval or force panels together in sewing.

Image placeholder — Corrective-action implementation photographs

9 Preventive actions

9 1 Supplier manufacturing prevention

- Control yarn/elastane lot approval and placement.
- Verify construction across greige width.
- Establish machine-specific tension and take-up controls.
- Reduce fabric tension in wet processing and handling.
- Validate stenter, drying, compaction, sanforizing or heat setting for the actual fabric.
- Inspect after defined relaxation, not only under machine tension.
- Control winding tension, roll geometry and dispatch moisture.
- Retain samples and actual process records.

9 2 Delivery prevention

- Verify container cleanliness, dryness and integrity.
- Use approved moisture barrier and roll support.
- Avoid floor/wall contact where condensation may occur.
- Define stacking, restraint and loading limits.
- Escalate wet wrapping, leakage, condensation or damaged rolls.

9 3 Factory warehouse prevention

- Check package and roll condition at receipt.
- Monitor temperature, relative humidity, water entry and monsoon risk.
- Keep rolls supported and clear of wet surfaces.
- Preserve identity and quality status.
- Define opening, conditioning, storage-duration and stack controls.

9 4 Cutting prevention

- Verify pattern and marker scale.
- Set relaxation from demonstrated stability.
- Use qualified width zones and minimum controlled spreading tension.
- Limit lays according to trial results.

- Measure critical panels after rest.
- Preserve roll-zone-lay-ply traceability.

9 5 Garment process prevention

- Stop mismatched panels before sewing.
- Validate feed, thread tension and component compatibility.
- Validate actual fusing, washing, drying and pressing.
- Inspect after cooling and rest.
- Feed failures back to the source roll and recovery route.

Image placeholder — Supplier and factory prevention control plan

Image placeholder — Updated SOP and training records

10 Implementation summary

Action	Accountable owner	Gate	Evidence
Contain rolls and WIP	Factory QA	Immediate	Reconciled inventory
Provide yarn-to-dispatch dossier	Supplier QA	Before cause decision	Complete records
Verify pattern, marker and cutting system	Factory technical	Before material conclusion	Reference comparison
Map all affected rolls	Factory fabric QA	Before release	Roll maps
Investigate transport and monsoon exposure	Supplier logistics/factory receiving	Before attribution	Condition and exposure evidence
Confirm cause	Joint technical leads	Before permanent correction	Repeatable comparison
Correct supplier process	Relevant mill owner	Before new bulk release	Passing confirmation trial
Qualify narrow marker	Factory technical/QA	Before affected bulk cutting	Panels and garments pass
Sign recovery terms	Commercial leads	Before bulk recovery	Written agreement
Monitor recovered production	Process QA	During production	Traceable checks

Action	Accountable owner	Gate	Evidence
Verify subsequent lots	Supplier and factory QA	Agreed period	No recurrence

All actions were completed between 10 June and 28 July 2026. Supplier QA and the factory quality manager jointly signed effectiveness closure on 12 August 2026 after the third conforming follow-up lot.

Image placeholder — Implementation timeline

Image placeholder — Before and after comparison

11 Outcome evaluation

11.1 Before versus after metrics

Metric	Baseline	After correction/recovery	Requirement	Status
Waviness severity	9–24 mm amplitude	0–5 mm after supplier correction	≤5 mm under relaxed assessment	Closed
Panel mismatch	8–22 mm	0–3 mm	≤4 mm	Closed
Cutting rejection	14.8% in initial normal-marker trial	1.2% under controlled recovery	≤2.0%	Closed
Garment rejection	7.6% in initial 120-piece trial	0.38% in recovered bulk	≤1.0%	Closed
Marker consumption	1.84 m/garment normal baseline	1.97 m/garment narrow route	Approved ≤2.00 m	Closed
Recovered quantity	0 m before qualification	5,380 m released for controlled use	Documented roll-specific recovery	Closed

Metric	Baseline	After correction/recovery	Requirement	Status
Subsequent-lot recurrence	28 affected rolls in case lot	0 affected rolls in next three lots/25,460 m	No recurrence	Closed

11.2 Sustainability verification

Verify machine calibration, supplier release records, environmental logs, incoming checks, roll maps, marker restrictions, garment quality and customer results over the agreed subsequent lots and seasonal conditions.

Effectiveness was verified through three subsequent lots totaling 25,460 m. Compactor overfeed remained within ± 1.0 percentage point across width, winding tension remained within 28–32 N, all rolls passed relaxed-flatness inspection and no waviness-related panel or garment rejection was recorded.

Image placeholder — Improvement and recovery-yield chart

Image placeholder — Weekly monitoring dashboard

12 Conclusion

Fabric waviness is a supply-chain stability problem whose origin, activation and amplification may occur at different stages. In this simulated case, the high-low panel condition was traced to a supplier compactor overfeed imbalance and excessive winding tension. Monsoon humidity activated the stored strain, while inadequate factory relaxation amplified the operational effect.

The case requires controlled evidence from yarn through finished garment. Supplier processes, transport and monsoon exposure, warehouse storage, relaxation, spreading, cutting and garment finishing must each be evaluated within their controlled variables. Responsibility is assigned from verified cause and containment evidence.

Affected fabric was used only through a roll-specific validated route. The approved 168 cm marker specified placement, usable zones, 36-hour fabric relaxation, maximum 40-ply lays, 24-hour panel rest, first-bundle measurement and downstream verification. This recovered 5,380 m while 260 m was rejected and replaced. Garment conformity remained mandatory throughout the commercial recovery agreement.

Image placeholder — Final lessons and long-term controls infographic

13 Appendices

Appendix A Roll assessment and release record

Record field	Entry
Case and material	Case ID ____ Article ____ Batch ____
Roll identity	Original ID ____ Sub-roll ID ____ Length ____
Exposure	Transit/storage dates ____ Monsoon/wet evidence ____
Zone qualification	Meter interval ____ Width boundaries ____
Cutting route	Marker/revision ____ Width ____ Placement ____
Handling	Conditioning ____ Relaxation ____ Spreading ____ Lay limit ____
Evidence	Inspection ____ Panel trial ____ Garment trial ____
Disposition	Hold / Normal / Narrow marker / Reprocess / Reject
Authority	QA ____ Date ____ Restrictions ____

Appendix B Fabric and panel measurement record

Record field	Entry
Sample	Roll ____ Meter ____ Width zone ____ Layer ____
Environment	Temperature ____ RH ____ Conditioning ____
Fabric observation	Waviness class ____ Direction ____ Severity ____
Cutting method	Pattern ____ Marker ____ Lay ____ Ply ____
Initial measurement	Panel A ____ Panel B ____ Mismatch ____
After rest	Conditions ____ A ____ B ____ Mismatch ____
Acceptance	Requirement ____ Reference ____ Pass/Fail ____
Verification	Measured by ____ Verified by ____ Date ____

Appendix C Supplier and factory recovery agreement

Record field	Entry
Parties and stock	Supplier ____ Factory ____ PO ____ Rolls ____
Approved route	Marker/placement ____ Excluded zones ____ Trial ____
Consumption basis	Baseline ____ Recovery ____ Comparable assortment ____
Cost allocation	Extra fabric ____ Inspection ____ Recutting ____ Other ____

Record field	Entry
Existing WIP	Replacement ____ Recut ____ Reject ____
Stop procedure	Trigger ____ Hold scope ____ Reassessment authority ____
Approvals	Supplier ____ Factory QA ____ Technical ____ Commercial ____
Customer approval	If applicable ____ Date ____ Reference ____

Appendix D Corrective action and effectiveness record

Record field	Entry
Action	ID ____ Process ____ Accountable person ____
Cause evidence	Confirmed/open hypothesis ____ Reference ____
Correction	Containment ____ Permanent action ____ Prevention ____
Schedule	Due ____ Implemented ____ Status ____
Verification	Trial ____ Requirement ____ Follow-up lots ____
Effectiveness	Result ____ Recurrence ____ Evidence ____
Closure	Close/remain open ____ Reason ____
Approval	Verified by ____ QA ____ Date ____

Appendix E Quantity reconciliation

Quantity group	Meters or kilograms	Roll IDs	Evidence
Received	8,760 m	R001–R042	Receipt SIM-GRN-017
Normal release	2,920 m	R001–R002 and R031–R042	Release NR-017
Narrow-marker release	4,960 m	Qualified zones of R003–R030	Authorization SIM-RA-017
Section-removal release	420 m	Sub-rolls from R011, R018, R023 and R027	Sub-roll maps
Reject/return	260 m	Failed zones from R008, R014, R022 and R029	Supplier replacement note
Sampling/cutting loss	200 m	Across affected roll group	Trial and loss record
Converted WIP/garments	5,380 m recovered route; 9,684 garments	Roll-zone-lay traceability	Bulk recovery register

Appendix F Technical references

1. CottonWorks — Shrinkage and Skewing (<https://cottonworks.com/learning-hub/quality-assurance/shrinking-and-skewing/>): construction, processing tension, relaxation and finishing.
2. CottonWorks — Mechanical Finishing (<https://cottonworks.com/learning-hub/finishing/mechanical-finishing/>): relaxation drying and compaction.
3. Coats — Eliminating Seam Puckering (<https://www.coats.com/id/info-hub/eliminating-seam-puckering/>): separation of sewing and dimensional-instability mechanisms.
4. ASTM D1776/D1776M (https://store.astm.org/d1776_d1776m-20r24.html): conditioning framework when specified by the applicable textile test.
5. ASTM D3882 (<https://store.astm.org/d3882-08r20.html>): bow and skew measurement; not a complete waviness method.

These references guided the simulated investigation method. The case conclusions were established from the simulated process records, measurements and controlled trials stated in this report.

Image placeholder — Raw data and process map

Image placeholder — Additional evidence photographs