

Enterprise Container, Serverless, and Kubernetes Security Governance on AWS

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Specialization: Cloud Security & Cloud-Native Security

Platform: Amazon Web Services (AWS)

1. Introduction

This document describes the design, implementation, and validation of security controls for containerized, serverless, and Kubernetes workloads in AWS.

I implemented this framework to ensure that container images, Kubernetes workloads, and Lambda functions operate securely, follow least-privilege principles, and prevent vulnerability exploitation and secrets exposure.

The solution integrates vulnerability management, identity governance, secrets management, and runtime security controls.

2. Objectives

The primary objectives were to:

- Secure container images before deployment
- Detect and remediate vulnerabilities in ECR
- Enforce least privilege for Lambda execution roles
- Prevent secrets leakage
- Enforce Kubernetes workload security standards
- Implement RBAC for container workloads
- Validate security controls through testing

3. Container Image Security (Amazon ECR)

3.1 Vulnerability Scanning

A private Amazon ECR repository was created to store container images.

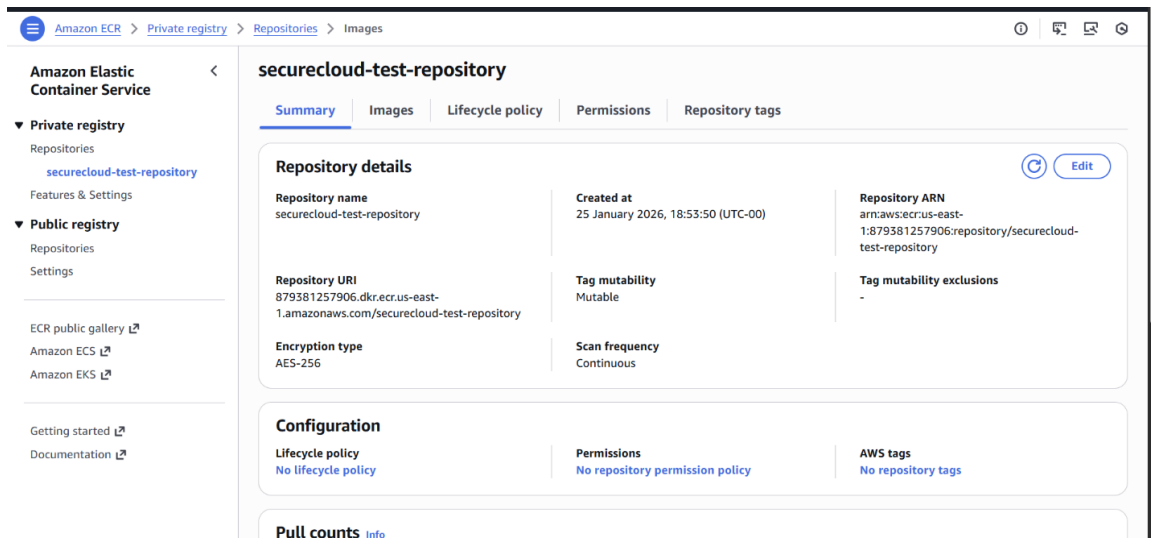


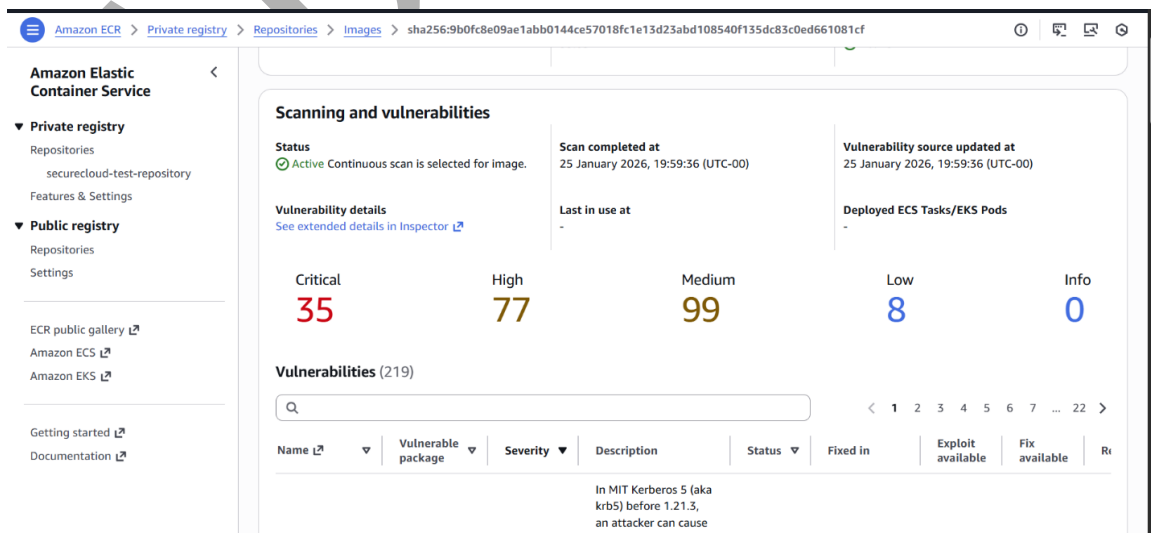
Image scanning on push was enabled and integrated with Amazon Inspector for continuous vulnerability assessments.

Images are automatically scanned for CVEs and categorized by severity.

3.2 Vulnerability Testing

A test image (nginx:1.18) was pushed to ECR and scanned.

Multiple vulnerabilities were detected and documented.

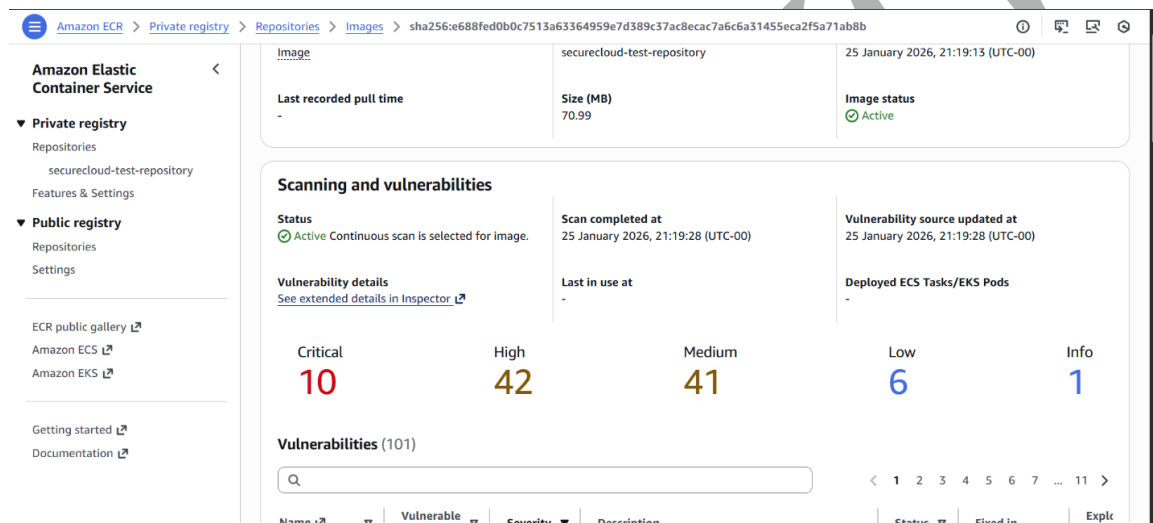


3.3 Remediation Process

To remediate vulnerabilities:

- Base images were upgraded (nginx:1.25)
- Containers were rebuilt
- Updated images were rescanned

Scan results confirmed reduced risk levels.



3.4 Secure Image Lifecycle

Only compliant images are approved for deployment.

Insecure images are blocked until remediation is completed.

4. Serverless Security (AWS Lambda)

4.1 Execution Role Review

Lambda execution roles were reviewed for:

- Wildcard permissions
- Overly broad managed policies
- Unnecessary service access

4.2 Least Privilege Enforcement

Broad permissions were removed and replaced with scoped policies.

Roles were limited to required services, actions, and resources.

Baseline logging permissions were retained.

4.3 Validation Testing

Functions were tested after permission reduction.

CloudWatch logs confirmed successful execution.

AccessDenied errors were used to validate permission boundaries.

5. Secrets Management and Leakage Prevention

5.1 Secure Secrets Storage

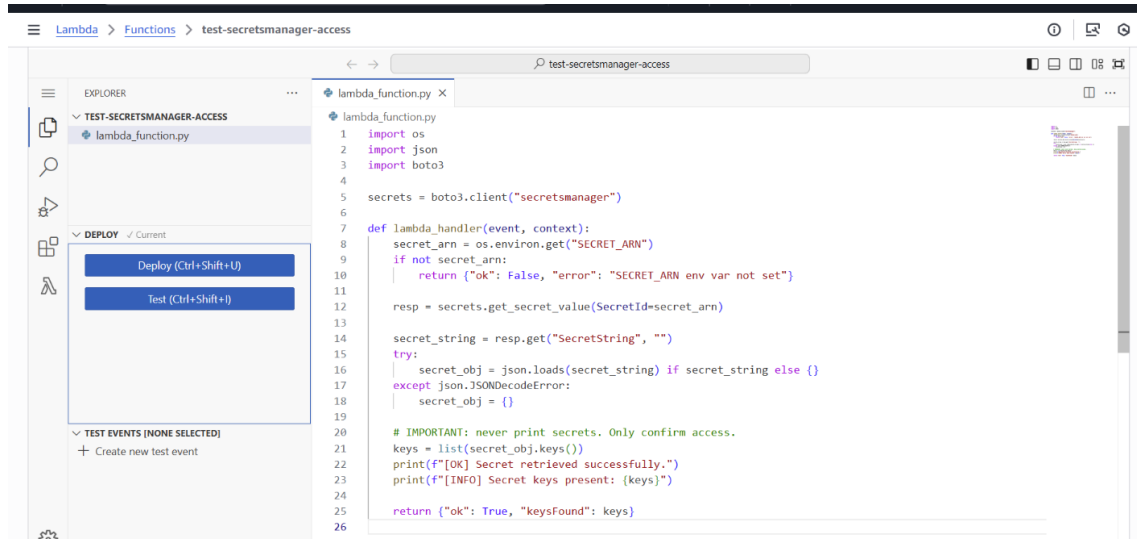
Sensitive credentials were migrated to AWS Secrets Manager.

Secrets were encrypted using KMS.

No plaintext secrets were stored in environment variables.

5.2 Secure Access Design

Lambda functions were configured with:

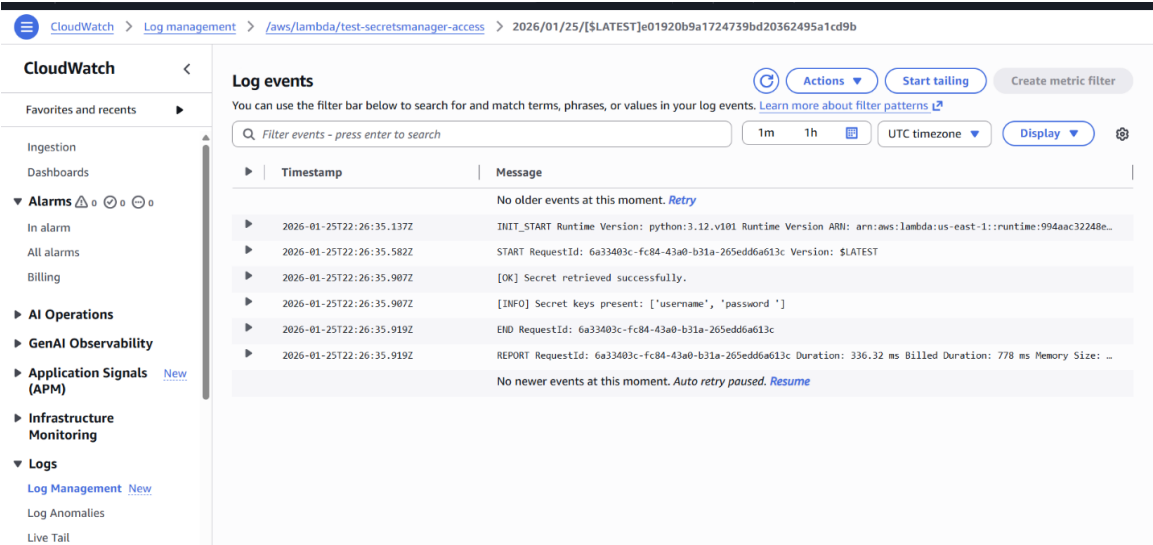


- secretsmanager:GetSecretValue permission
- Access scoped to specific secret ARNs



5.3 Validation

Secrets retrieval was tested successfully.



Permission removal resulted in expected failures.

This confirmed strict access control.

6. Kubernetes Workload Security (Amazon EKS)

6.1 Namespace Isolation

Separate namespaces were created for staging and production environments.

This prevents cross-environment access and supports tiered controls.

6.2 Pod Security Standards Enforcement

Pod Security Standards were enforced using namespace labels:

- Production: Restricted policy
- Staging: Baseline policy

```
Windows PowerShell
45337c09cd57: Pushed
933cc8470577: Pushed
nginx-1.25: digest: sha256:e688fed0b0c7513a63364959e7d389c37ac8ecac7a6c6a31455eca2f5a71ab8b size: 2295

Info → Not all multiplatform-content is present and only the available single-platform image was pushed
sha256:a484819eb60211f5299034ac80f6a681b06f89e65866ce91f356ed7c72af059c -> sha256:e688fed0b0c7513a63364959e7d389c37ac8ecac7a6c6a31455eca2f5a71ab8b

PS C:\Users\Green> kubectl version --client
Client Version: v1.32.2
Kustomize Version: v5.5.0
PS C:\Users\Green> aws eks update-kubeconfig --region us-east-1 --name securecloud-eks-cluster
Added new context arn:aws:eks:us-east-1:879381257986:cluster/securecloud-eks-cluster to C:\Users\Green\.kube\config
PS C:\Users\Green> kubectl get nodes
No resources found
PS C:\Users\Green> kubectl get nodes
NAME STATUS ROLES AGE VERSION
i-031f4289605a86bfd Ready <none> 15h v1.34.3-eks-3c60543
PS C:\Users\Green> kubectl create namespace staging
namespace/staging created
PS C:\Users\Green> kubectl create namespace production
namespace/production created
PS C:\Users\Green> kubectl label namespace staging pod-security.kubernetes.io/enforce=baseline --overwrite
namespace/staging labeled
PS C:\Users\Green> kubectl label namespace production pod-security.kubernetes.io/enforce=restricted --overwrite
namespace/production labeled
PS C:\Users\Green> kubectl get ns staging production --show-labels
NAME STATUS AGE LABELS
staging Active 72s kubernetes.io/metadata.name=staging,pod-security.kubernetes.io/enforce=baseline
production Active 69s kubernetes.io/metadata.name=production,pod-security.kubernetes.io/enforce=restricted
PS C:\Users\Green>
```

6.3 Policy Validation

Privileged containers were blocked in production.

Compliant workloads were permitted in staging.

```
Windows PowerShell
45337c09cd57: Pushed
933cc8470577: Pushed
nginx-1.25: digest: sha256:e688fed0b0c7513a63364959e7d389c37ac8ecac7a6c6a31455eca2f5a71ab8b size: 2295

Info → Not all multiplatform-content is present and only the available single-platform image was pushed
sha256:a484819eb60211f5299034ac80f6a681b06f89e65866ce91f356ed7c72af059c -> sha256:e688fed0b0c7513a63364959e7d389c37ac8ecac7a6c6a31455eca2f5a71ab8b

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Client Version: v1.32.2
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Added new context arn:aws:eks:us-east-1:879381257986:cluster/securecloud-eks-cluster to C:\Users\Green\.kube\config
PS C:\Users\Green> kubectl get nodes
No resources found
PS C:\Users\Green> kubectl get nodes
NAME STATUS ROLES AGE VERSION
i-031f4289605a86bfd Ready <none> 15h v1.34.3-eks-3c60543
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PS C:\Users\Green> kubectl create namespace production
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PS C:\Users\Green> kubectl label namespace production pod-security.kubernetes.io/enforce=restricted --overwrite
namespace/production labeled
PS C:\Users\Green> kubectl get ns staging production --show-labels
NAME STATUS AGE LABELS
staging Active 72s kubernetes.io/metadata.name=staging,pod-security.kubernetes.io/enforce=baseline
production Active 69s kubernetes.io/metadata.name=production,pod-security.kubernetes.io/enforce=restricted
PS C:\Users\Green> kubectl apply -f bad-pod.yaml
error: the path "bad-pod.yaml" does not exist
PS C:\Users\Green> kubectl apply -f bad-pod.yaml
Error from server (Forbidden): error when creating "bad-pod.yaml": pods "bad-pod" is forbidden: violates PodSecurity "restricted:latest": privileged (container "nginx" must not set securityContext.privileged=true), allowPrivilegeEscalation != false (container "nginx" must set securityContext.allowPrivilegeEscalation=false), unrestricted capabilities (container "nginx" must set securityContext.capabilities.drop=["ALL"]), runAsNonRoot != true (pod or container "nginx" must set securityContext.runAsNonRoot=true), seccompProfile (pod or container "nginx" must set securityContext.seccompProfile.type to "RuntimeDefault" or "Localhost")
PS C:\Users\Green>
```

```
Windows PowerShell
45337c09cd57: Pushed
933cc8470577: Pushed
nginx-1.25: digest: sha256:e688fed0b0c7513a63364959e7d389c37ac8ecac7a6c6a31455eca2f5a71ab8b size: 2295

Info + Not all multiplatform-content is present and only the available single-platform image was pushed
sha256:a484819eb0211f5299034ac80f6a681b06f89e65866ce91f356ed7c72af059c -> sha256:e688fed0b0c7513a63364959e7d389c37ac8ecac7a6c6a31455eca2f5a71ab8b

PS C:\Users\Green> kubectl version --client
Client Version: v1.32.2
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PS C:\Users\Green> kubectl get nodes
No resources found
PS C:\Users\Green> kubectl get nodes
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namespace/staging created
PS C:\Users\Green> kubectl create namespace production
namespace/production created
PS C:\Users\Green> kubectl label namespace staging pod-security.kubernetes.io/enforce=baseline --overwrite
namespace/staging labeled
PS C:\Users\Green> kubectl label namespace production pod-security.kubernetes.io/enforce=restricted --overwrite
namespace/production labeled
PS C:\Users\Green> kubectl get ns staging production --show-labels
NAME STATUS AGE LABELS
staging Active 72s kubernetes.io/metadata.name=staging,pod-security.kubernetes.io/enforce=baseline
production Active 69s kubernetes.io/metadata.name=production,pod-security.kubernetes.io/enforce=restricted
PS C:\Users\Green> kubectl apply -f bad-pod.yaml
error: the path "bad-pod.yaml" does not exist
PS C:\Users\Green> kubectl apply -f bad-pod.yaml
Error from server (Forbidden): error when creating "bad-pod.yaml": pods "bad-pod" is forbidden: violates PodSecurity "restricted:latest": privileged (container "nginx" must not set securityContext.privileged=true), allowPrivilegeEscalation != false (container "nginx" must set securityContext.allowPrivilegeEscalation=false), unrestricted capabilities (container "nginx" must set securityContext.capabilities.drop=["ALL"]), runAsNonRoot != true (pod or container "nginx" must set securityContext.runAsNonRoot=true), seccompProfile (pod or container "nginx" must set securityContext.seccompProfile.type to "RuntimeDefault" or "Localhost")
PS C:\Users\Green> kubectl apply -f good-pod.yaml
pod/good-pod created
PS C:\Users\Green> kubectl get pods -n staging
NAME READY STATUS RESTARTS AGE
good-pod 0/1 ContainerCreating 0 29s
PS C:\Users\Green>
```

This confirmed enforcement effectiveness.

7. Kubernetes Role-Based Access Control (RBAC)

7.1 RBAC Design

A dedicated service account (app-sa) was created.

Namespace-scoped roles were defined with read-only permissions.

7.2 Role Binding

RoleBindings were configured to associate roles with service accounts.

7.3 Authorization Testing

The service account could list pods.

Access to delete pods and secrets was denied.


```
Windows PowerShell
Copyright (C) Microsoft Corporation. All rights reserved.

Install the latest PowerShell for new features and improvements! https://aka.ms/PSWindows

PS C:\Users\Green> kubectl create serviceaccount app-sa -n staging
serviceaccount/app-sa created
PS C:\Users\Green> kubectl apply -f pod-reader-role.yaml
role.rbac.authorization.k8s.io/pod-reader created
PS C:\Users\Green> kubectl apply -f pod-reader-binding.yaml
rolebinding.rbac.authorization.k8s.io/pod-reader-binding created
PS C:\Users\Green> kubectl run rbac-test --image=nginx:1.25 -n staging
pod/rbac-test created
PS C:\Users\Green> kubectl get pods -n staging
NAME      READY   STATUS    RESTARTS   AGE
rbac-test 0/1     ContainerCreating   0          25s
PS C:\Users\Green> kubectl auth can-i list pods -n staging --as=system:serviceaccount:staging:app-sa
yes
PS C:\Users\Green> kubectl auth can-i delete pods -n staging --as=system:serviceaccount:staging:app-sa
no
PS C:\Users\Green> |
```

This validated least-privilege enforcement.

8. Governance and Operational Controls

All container, Lambda, and Kubernetes security controls were documented.

Standard operating procedures were established for:

- Image remediation
- Permission reviews
- Secrets rotation
- Policy updates

9. Testing and Validation Framework

Security controls were validated through:

- ECR vulnerability remediation testing
- Pod Security enforcement testing
- RBAC authorization testing
- Lambda permission testing

- Secrets access validation

All controls operated as intended.

10. Outcomes and Impact

This implementation delivered:

- Reduced container vulnerability exposure
- Secure serverless execution roles
- Protected secrets management
- Enforced Kubernetes security standards
- Strong workload isolation
- Improved cloud-native security posture

11. Conclusion

I designed and implemented an enterprise-grade security governance framework for containerized, serverless, and Kubernetes workloads on AWS.

Through integrated vulnerability management, identity controls, secrets protection, and runtime enforcement, this solution ensures secure and resilient cloud-native operations.